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The MONTHLY REVIEW

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A Society
for the Advancement of the Science of
Electro-Plating

OCTOBER 1936 · IN THIS ISSUE

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Cooperation!

Now that the fall and winter activities have begun in all the branches, the most important word in our vocabulary is "cooperation." Without it we cannot achieve our objective either as branches or as an entire organization. The plating industry is becoming so important that we as members of the American Electro-Platers' Society must work together unanimously if we are to make the year 1936-37 the most eventful and far reaching in our history. To this end, therefore, we are asking cooperation with our first vice-president, Mr. P. J. Sheehan, chairman of the Membership Committee in his program to increase the number of members. There is a great opportunity in this field as many platers are still outside the A.E.S. who should be working with us and receive the benefits and educational advantages the Society offers. There are also many assistant foremen who need further training in order to prepare them for promotion where the opportunity arises. These men need to make contacts and form associations with those more experienced in the trade and the best way to do this is to sign up as members of the A.E.S. Let us help the Membership Committee in its drive for new members.

In order to have a successful convention each year, it is necessary to have cooperation. New York Convention Committee needs the help of all the branches during the coming months. Particularly do we need papers from the plating room foremen. We have heard criticisms from some sources that our convention papers are too technical. Well, we are glad to have the technical men give us their time and effort. They have been a great help and have lent a lot of dignity to our organization and have shown a willingness to cooperate. In asking our own members to cooperate therefore we do not by any means try to discount the value of the trained technical man's contribution to our educational sessions. Many of these men being so interested in our progress that they have become associate members and have helped considerably in the activities of the local branches as well.

We are making this plea now that the 1937 convention be distinctive and unusual because many of our foremen have the society's interest enough at heart to prepare and present papers dealing with some phase of their work, the problems they encoun-

tered and the means taken to overcome these problems. This would make a most interesting and helpful series of educational sessions at the next convention.

While visiting plating and other finishing departments in the various manufacturing plants, one cannot help being amazed at the beautiful array of finishes produced by our members. There are the lovely oxidized shades produced on casket hardware, builders hardware, and the materials used to supply the electrical industry. The cash register manufacturers produce lacquered enamelled and plated finishes that are excellent specimens of workmanship. Then there are typewriters, automobiles, motor appliances for the home — refrigerators, radios, etc., all demonstarting the skill and cunning of the platers art. Why not have a real display of plated goods on exhibition at the New York Convention? The manufacturers will be glad to cooperate with the platers and will, we believe, be willing to pay the expenses of exhibiting, if they are approached on the subject. It might even be possible to advertise such an exhibit and charge the public a small admission fee. This would give outsiders an opportunity to enjoy a real exhibition of finishes on metals and would prove most interesting and instructive. If this organization is to have a place in the sun, the local branches must do more to help than they have in the past. Our trouble has always been that we have kept our light hidden under a bushel. It is time we became aggressive and advertised ourselves. In the great metropolis with its millions of people, we have a golden opportunity to put our society on the map by displaying our handiwork and thus telling the world that in the home, the office, the auto, and in every other walk of life, the skill of the plater is becoming more and more manifest, as plated ware becomes more of a necessity. It would be a grand spectacle indeed to have a contribution from all our branches in 1937. *And with very little effort it can be done*!

Incidentally your secretary will be glad to cooperate in this movement and will be pleased to get in touch with the various manufacturing concerns if the members of the branches so desire. Begin now, talk it over at the next branch meeting, then with your help, through the pages of THE REVIEW and the personal work of this office, we will put on an exhibition of plated articles that will be remembered for years to come. All that is necessary is your earnest cooperation.

COOPERATION WITH OUR ADVERTISERS:

In order to carry on the work of the Executive-Secretary, your cooperation is needed. Several new publications have recently appeared in the metal cleaning and finishing field which makes it harder to secure the necessary amount of advertising to pay expenses. We appeal at this time to our membership to be loyal to their own publication and also to show their loyalty to our adver-

tisers who have stayed with us so consistently. These companies have helped our Society tremendously in the last few years both morally and financially. Let us show our gratitude in return by giving them the preference over others who are not willing to cooperate. Point out to your supply house representative the advantage of an ad in our own publication and show by your interest in this respect that you are doing your part to cooperate in all the enterprises sponsored by your organization, the A.E.S.

A Call to All Members of the A.E.S.

We will celebrate the twenty-fifth anniversary of our society at the convention to be held in New York City next June. We want every member to do his share towards making this, our Silver Jubilee year, the most successful of our existence.

It is essential, if we are to make this a successful year, to increase our membership. Our society cannot occupy the position to which it is entitled until every man who is eligible is a member. Let us ask ourselves this question: Why must every man who is eligible be a member of our society before we can take our rightful place in the sun? We might answer with an old proverb — "A chain is no stronger than its weakest link." We must see every eligible man a member so that we may all learn to speak the same language and make the weak strong, thereby strengthening ourselves and our society. Only in this manner can we attain our rightful place in industrial life.

At the Bridgeport, Connecticut, Convention in 1934, the constitution was amended so that eligible assistant foremen could become members. Have you brought your assistant into the society? If not, you are passing up a good bet. A well trained assistant can prove to be your guardian angel rather than a menace. Where could he get better training than at the branch meetings?

We need every plater, every assistant and every eligible chemist in our society so that we may be able to set up and teach standards of ethics. It is not the member of our society who is a menace to you, but rather the man who is not a member.

Let us look at some other professions and see whether organization has added to or detracted from their prestige. Take the medical profession for example. Their organization leaves no stone unturned until all eligibles are members of the medical society, with the result that the doctor of today is a far superior individual to the doctor of yesterday. They cannot afford to have doctors running loose outside of their organization. Nor can the individual afford the lowering of his professional standard by remaining outside. And so it is with other professions — The Bar Association, American Chemical Society, American Welding

Society, Electro-Chemical Society, etc. They cannot afford to have eligibles running loose and neither can the A.E.S. Every properly qualified man belongs within our society.

We are now laying the ground work for a membership drive. A "live-wire" member will be appointed in your district to direct the drive. Give him all the aid you can. He is entitled to it for he is working for your advancement.

All you traveling members who contact so many people in our line — give us a hand. Talk and sell A.E.S. I certainly would like to be able to report at the convention next June that each one of you, by bringing a new member to our society, did his share toward making this our banner year.

P. J. SHEEHAN

Available Speakers at Branch Meetings

I wish at this time to thank the officers and members of the entire Society, for the kindly interest they have manifested in my letters of inquiry to the Branch Societies relative to speakers available for our different branches.

I also wish to thank the following firms, who have one or more speakers in their company, and the individual speakers for their interest and willingness to speak before the various branches.

Dr. W. Blum, U. S. Bureau of Standards, Washington, D. C.
Hanson-Van Winkle-Munning Co., Attention Mr. C. W. Yerger, Matawan, New Jersey.
Mr. W. M. Phillips, Research Division, General Motors Corp., Detroit, Mich.
Oakite Products Corp., 22 Thames St., New York, Attention Mr. J. Carter.
R. & H. Division, E. I. Du Pont De Nemours & Co., Wilmington, Delaware.
A. T. Wagner Co., 2700 Wight St., Detroit, Mich., Attention Mr. J. Hoefer.
F. Gumm Chemical Co., 113 36th St., Union City, N. J., Att. Mr. F. Gumm.
Mr. W. R. Meyer, General Electric Co., Bridgeport, Conn.
Crown Rheostat & Supply Co., 1910 Maypole Ave, Chicago, Ill., Att. Mr. G. Spencer.
The Udylite Co., 1651 E. Grand Blvd., Detroit, Mich, Att. Mr. G. Soderberg.
General Abrasive Co., Niagara Falls, N. Y., Att. Mr. W. W. Dobkin.
G. S. Blakeslee & Co., 19th & 52nd Ave., Cicero, Ill., Att. Mr. J. W. Dammers.

I take this time to thank the following members for their kind assistance in abstracting the many papers that appear under my jurisdiction as second Vice-President in charge of this department of the society. Mr. W. R. Meyer, Dr. W. Blum, Mr. F. D. Rossini, Mr. E. C. Sheehan, Mr. C. T. Thomas, Mr. P. J. Ritzenthaler, Mr. M. V. Sheehan, Mr. W. Geissman.

My reason for addressing you at this time is because of the prominence and capability of the list of speakers herewith. I believe that every branch should avail themselves of the opportunity to hear as many of these lectures as they can and make their arrangements with the speakers, as soon as possible. The subjects will be profitable to all.

J. W. HANLON

The Commercial *and* Practical *Aspects of* Throwing Power *as a Factor in the* Character *of Deposits*

By DONALD WOOD

Read at Cleveland Convention 1936

ON going into the silver plating field I found a basic problem I had never experienced in plating other metals. Finding no satisfactory solution of this problem in the textbooks and literature on plating, I have spent a part of the last two years working on it. Now I wish to report on this work with the hope that my facts and your criticism may add a useful thought on the mechanics of electrodeposition.

Although all of my observations and experimental work are on silver solutions, it should not be assumed that the possible conclusions are not generally applicable.

I am called on to silver plate tea-ware made of 10% N. S. and of W. M., a high tin alloy. It happens that a particular style of tea-pot is made both ways. The 10% N. S. pot presents no difficulty in plating the inside and the W. M. one considerable difficulty. By special treatment, this difficulty is overcome but if exactly the same procedure is used for the two pots, a good coating of silver is obtained on the inside of the N. S. one and the W. M. comes from the tank with only patches of silver on the inside and under some circumstances, etching of the W. M. It seemed possible that this might be caused by the known difference in the conductivity of the two alloys. This possibility was disproved when an almost identical W. M. pot happened to be supplied with a copper bottom. The copper bottom plated perfectly and the W. M. side walls not only failed to plate but lost the strike deposit. This seemed satisfactory evidence that potential differences on the original cathode surface were involved.

I had assumed that if a piece of work went into a tank with a visible complete coverage of silver, that any possible potential differences existing on the original surface were destroyed. Here was evidence to the contrary.

Another shop problem supplies further evidence. Much silver-plated ware is made of 10% N. S. with W. M. castings soldered

on. Under some circumstances these W. M. parts or the solder or both come from the tank with no silver even though well covered in the strike.

These are both well known problems in the silver industry and the practical solution presents no great difficulty. They are cited here to show that an apparent complete coverage of a cathode surface does not erase the possible influence of the original surface.

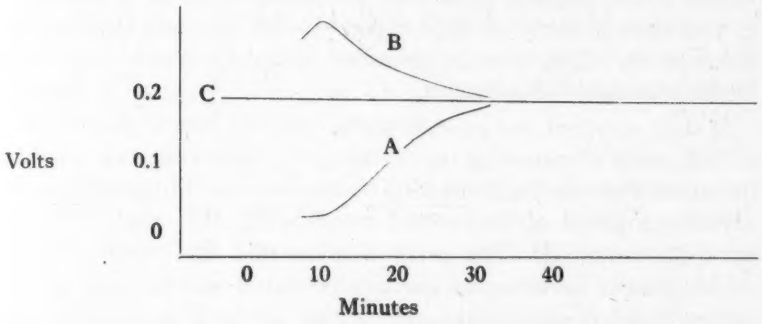
Later investigation has shown that another phenomenon common in silver plating is related to those described, so I will mention it here although the relationship will not appear at once. The structure of the basis metal sometimes appears in the deposit even though observation of a section shows no characteristic basis metal effect. By this is meant that a normal conical or broken structure is observed in the section with little evidence of basis metal boundaries continuing — while the surface may have the appearance of an etched section of the basis metal.

Two well known examples of this effect are the commonly known "gray bowls" in plating spoons and the appearance of an etched white metal surface in a silver deposit on the inside bottom of a white metal bowl. In each case under the most favorable conditions, the apparent reproduction is almost perfect. If this reproduction could be observed in section it could be explained as due to continuation or growth of the original crystals, but where the despoit has a structure of its own as well, it seems necessary to furnish another explanation. A possible explanation came to light in the course of some work on cathode polarization.

We were dissatisfied with methods commonly used for measuring cathode polarization because it appeared impossible to obtain reproducible measurements and it seemed necessary to have such reproducibility before any conclusions could be reached. After a study of this question we found that vigorous agitation would allow satisfactory use of a modified Haring cell. By means of this agitation, concentration effects were satisfactorily eliminated and polarization could be held constant within .01 volt over periods of several hours after equilibrium was established.

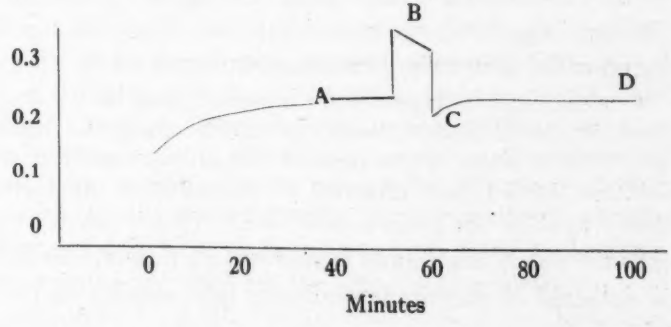
It was observed that when a new cathode was introduced into the solution and observations on polarization made at frequent intervals, a characteristic curve of polarization against time re-

sulted for each of two different methods of preparation. Figure 1 shows typical curves.



The line C is the equilibrium C/P value for the solution and operating conditions used. Curve A represents the transition to equilibrium for a silver cathode etched to reveal its coarse structure. Curve B represents a fine grained silver cathode with a buffed surface under identical conditions. Observations of this sort were made repeatedly and the general shapes found to be characteristic of the initial condition of the cathodes over a fairly wide range of solution and operating conditions.

Figure 2 is intended to show that the observations of Figure 1 are not caused by some type of carry over, such as a film or the temperature of the cathode.



Here a new cathode was observed to come to equilibrium after about thirty minutes. When no change was observed for another thirty minutes the C/D was increased roughly 100% with the

change in the C/P shown at B. After about ten minutes a new equilibrium appeared to be established and the C/D was returned to the original value with the change in the C/P shown at C and then a fairly prompt return to the original equilibrium value at D. This appears to prove that the cathode itself is a factor in cathode polarization.

If such an effect can exist, it seems possible that it may be due to difference of potential on the surface. Such differences could be caused even during deposition by the fact that the grain boundary is composed of unoriented metal while the crystal face is naturally oriented. The ratio of areas and the relative strain could cause a variation in average potential which, in all probability, is what we are measuring either in the Haring cell or by other means.

A simple experiment in the modified Haring cell illustrates this point. A small piece of W. M. is ground on a coarse polishing wheel and another piece buffed. When they are immersed in the silver plating solution a difference in potential of about 0.1 volt is observed. On a W. M. cathode suitable for the Haring cell, a stripe is ground similarly and the piece is struck and placed in the cell with a polarization of 0.1 volt. The cathode plates satisfactorily on the buffed area but no silver is found on the ground area. The fact that here as well as in the cases previously mentioned a strike coating disappears indicates that this original deposit is not continuous. In fact it is observed that if the strike deposit is continued sufficiently the plate covers uniformly. This again points to the probability that deposition is influenced by potential differences between microscopic areas.

One more plant observation may be of value here. If a W. M. bowl is plated under conditions which cause the basis metal structure to show in the deposit and this is removed from the solution, buffed, and returned to the solution, no further tendency to show the grain is observed. This is taken to indicate that the nearly amorphous buffed surface presents no differences in potential of magnitude similar to that existing on the W. M. surface.

I have noted above several instances where apparently potential differences have been an influence in the structure of the deposit. In the first instance cited where these potential differ-

ences were on large areas, I was able to overcome the effect of these differences by improving the throwing power of the solution. This was done with negligible change in cathode polarization by the addition of potassium chloride to improve the conductivity. It is reasoned that if throwing power can compensate for differences in potential on fairly large areas, then the same effect may be expected on microscopic areas.

The conclusion which I am attempting to substantiate is, (1) that potential differences exist on all but amorphous metal surfaces; (2) that potential differences exist on the growing cathode face; (3) that these differences, first on the basis metal and then on the growing face are a continuous influence on the nature of the deposit; (4) that the compensation for these differences depends on the throwing power of the solution and operating conditions; and (5) that the equilibrium structure is a function of the basis metal condition as well as of the solution and operating conditions.

The commercial significance of all this lies in the fact that if serious differences in thickness exist on microscopic areas, finishing becomes either a problem or impossible and corrosion resistance must be low on the lightly plated areas. In metals normally plated at high potentials, no evidence of these possible differences in original potential would be likely because the difference in potential on the surface would be small in relation to the applied potential. Wherever the applied potential is low enough so that the probable differences in potential on the surface or in the growing cathode face are large in proportion to the applied potential, the effect should be apparent. In silver plating the limiting maximum potential is generally accepted as 0.5 volt and plating is normally carried on at an average near one-half that value. Differences in potential of only 0.1 volt are large in proportion to this value but would be negligible if we were plating nickel at a potential of about 1.5 volts. It is probable that many of the observed difficulties in depositing zinc, brass and copper are similar to those described here for silver. (Applause)

DISCUSSION

PRESIDENT SLATTERY: Is there any discussion of this paper?

DELEGATE WALTER R. MEYER: Mr. Wood has given a paper that is about on the same idea as the one I am going to

give Tuesday evening. I think I can agree with him that the small-scale geometrical condition of the cathode will have quite an influence on the structure of the deposited coating, and I might cite a couple of instances where the grain boundaries seem to have entirely dissimilar potential or activity from the crystals themselves. For instance, Ewing Publow and Tuttle found chromium tended to deposit along the cementite areas in low carbon steel. It has been observed that when you deposit zinc on zinc at a low potential you get little isolated areas of piles of zinc. You do not seem to get a continuous deposition. I am going to try to show that that is due to another factor also, but there is quite a difference between the chemical activity at the grain boundary and at the body of the crystal. Of course, that is evidently the differential reaction when you etch the metal to look at it under the microscope. I do not know whether I got this straight or not. Did you say you obtained continuation of the crystal structure of the white metal by silver?

DELEGATE WOOD: Not a continuation. Microscopically it looks as if you had an etched white metal surface. Microscopically you can find only slight traces of it.

DELEGATE MEYER: The basis metal would be tetragonal and the deposited metal has a face-centered cubic structure which is entirely different crystallographically.

DELEGATE WOOD: I do not think what I am observing has anything to do with the structure of the base metal crystals. I think this is purely a microscopic effect.

DELEGATE MEYER: I think it is too. You observe the orientive effects of these little surfaces. I think I will be able to show you that very nicely by some slides which will be shown Tuesday evening.

DELEGATE WOOD: I had an interesting experience which might follow there. On nickel silver, which was annealed probably more than it should have been, it came out of the silver solution looking just like an etched nickel silver piece. You could not find anything to show that it was a reproduction. It was simply a microscopic effect.

DR. BLUM: I should like to call attention to this first diagram here. In this case you started out, I believe, with a fine-grained

silver deposit and in this other case you used a coarse-grained silver deposit. All we have to assume in that case is that under the conditions of temperature and current density used, the tendency of silver was to deposit at a grain size corresponding approximately to that polarization. In that case, if then you start to deposit silver on a fine-grain structure, your polarization is going to be initially higher than it will be as those crystals grow coarser. If you start on a coarse grain structure, the crystals are going to tend to become finer. So I think you could explain that, as you say, just on the basis of the crystal size rather than on any question of actual continuation of the crystal, that is, more on the crystal boundaries. Here you are starting to deposit fine silver and it gets coarser and here you are starting to deposit coarse silver and it gets finer. I think that at least would be consistent.

DELEGATE WOOD: I have one further observation that might help on that. In work on cathode polarization, we found that the time required to get to equilibrium was tremendous in some cases, even with the vigorous agitation which meant that you could get an equilibrium. We found that by starting with a cathode and running at low current density for half an hour we could then go to work on it and we would get polarization values as we increased the current density, which would come to equilibrium in ten seconds, until you would come to one point and it would take perhaps ten minutes there. We were fooled pretty badly on that for a while. We thought we had equilibrium when we did not have it. We would get curves that were full of inflections and were very unsatisfactory.

For instance, if a curve is going to ultimately look something like this (illustrating), which by the way is characteristic of this vigorous agitation, we might get all these points up to, say, here, in the matter of a few seconds, and then we get a point out here and for that to get up to here, that is, for that equilibrium to establish itself, it might take ten minutes, while all the rest of them occurred very quickly.

We probably all have observed the fact that where something is plating down inside of a hollow piece, particularly silver, there is a tendency for the deposit to occur in bands of apparently different orientations. I think what happens actually is that within a

narrow range, perhaps not a very narrow range, the structure is characteristic for a range of polarizations, and that as you cross a certain boundary of polarization then the deposit has to adapt itself to another characteristic structure. I shall try to draw a picture of that.

Suppose we have a piece shaped like this (illustrating). We may have one structure apparently homogeneous down to here. Then we will get a band. Prehaps this will be bright. Then we get a white band here. I have seen the same thing in other types of plating, although I am not good in describing them accurately. Then this will fade off a little bit and you get another bright section down here. That banding is very apparent in spot plating, I notice. There, if the agitation is pronounced, you will get one band which is very bright in among several bands of fairly white plate.

My conception of it is that we can change our polarization or the polarization can change itself over quite a wide range and then suddenly it has to snap over into a different channel. This is not well expressed, but if you have experienced that type of banding, I think you know what I mean.

MR. G. B. HOGABOOM (New Britain, Conn.): I should like to ask Mr. Wood whether he was certain that that piece of metal had a grain structure that was of the same size throughout or whether there was some cold work strain in the forming there that did not set up a difference of potential right at that article and that is what caused your white and your bright areas.

DELEGATE WOOD: I think I can satisfy you on that. Only a day or two ago we plated some square bowls heavily fluted at the corners. That is a drawing operation. The bands on those were very pronounced and they followed those flutes right around. There was absolutely no change in the distance from the rim of the bowl to the band even through those flutes. If there had been a cold working strain involved there, I do not think the band would have been as smooth as it was. It was a perfectly parallel-sided stripe; in fact, several stripes. That is not characteristic of just one or two occasions; that is not an examining of one or two occasions; it is characteristic. I have noticed it over a period of years — not many years, but years.

MR. A. E. THURBER (Sherrill, N. Y.): Had this metal been worked and annealed and then reworked?

DELEGATE WOOD: It had had several annealing operations.

MR. THURBER: That would necessarily give you quite a variety of grain structures.

DELEGATE WOOD: Yes! Let me point once more to the circles on the bottom of spot plated spoons where the same striping occurs. If it tied itself up to work strains, I am sure I would have observed it. It may be asking a lot for you to take my word for it.

Here is an example: We make a white metal bowl on which we solder some feet on the bottom at four points. I am on another track now so I might mention the feet. The metal is annealed in soldering sufficiently so that the metal shows sufficiently. Almost invariably in plating spun bowls, unless great care is taken to have sufficient throwing power to get a uniform potential from the bottom of the bowl, these rings will occur, and it is a matter of throwing power to establish a uniform potential to the bottom.

MR. THURBER: We have noticed for a long time the phenomena which you have been striking to overcome it in a practical way we have deposited nickel underneath the silver plating. That gets away from it very nicely. Put a thin layer of nickel on. That changes the throwing power, apparently, of the silver.

DELEGATE WOOD: That was the point I was trying to bring out; that throwing power does depend upon the metal surface, and I think that is a good way to explain it. It is a counter E.M. F. working against the compensating action of throwing power. You have to have more throwing power to overcome it. I have seen these rings occur in bowls and then by increasing the current density, we wiped them right out. So it is not a case of the structure of the metal in that particular instance. It is a case of the structure of the deposit there, I am sure.

MR. THURBER: What you have reference to is plating on the heel of a spoon where it is set on the surface of the solution.

DELEGATE WOOD: Yes! I will have to confess, I think, that we use a solution coming up under it, so that the agitation is variable from the center of the spot to the outside.

MR. D. OVERCASH (Syracuse, N. Y.): Is there any method by which we can raise the potential to get any finer deposits?

DELEGATE WOOD: I think the equilibrium potential is the function of two things: the solution and the operating condition and the original basis metal condition which by the time you have a deposit on there is having a very slight effect, but which did have an effect on the original structure so that it continues to layer. I think that is a continuous effect.

MR. OVERCASH: Would that graph be general in its application to other metals?

DELEGATE WOOD: The equilibrium value here depends on your solution. That is for a definite equilibrium. It is the solution and the deposit that you are making. You cannot get away from the fact that you have to deposit the next atom of silver on the previous one; so no matter what you do, the next coating is going to be dependent upon the one immediately preceding. For that reason your basis metal has an effect no matter how far you go.

For example, if you plate on a well annealed brass, an etched surface, you can get a perfect picture of that brass structure in the silver, or probably in several other metals. Let us talk about copper. You can etch a piece of copper and get perfect continuation of the original grains. There are plenty of pictures of that. There is nothing you can do to start a fine-grained deposit so far as I know on a cast copper surface that has been etched. I erhaps Dr. Graham would comment on whether or not that is so. I do not think you can do it. Therefore, I say that the original surface is always a factor in the equilibrium structure. I want to mention once more that equilibrium structure may not be established while you are doing the plating job in practice. Two ten-thousandths of silver is rarely an equilibrium structure.

MR. HOGALOOM: You have to establish it after the silver has been deposited so you get a different effect between the silver in the solution rather than between the basis metal and the solution. While I recognize that you use silver as a cathode still you had a piece of fabricated metal which had an already different structure from what you would use in electrodeposited metal.

DELEGATE WOOD: I tried to cover both of these conditions. In the first case, the original differences in potential are due to possibly many things, but essentially the grain in the unoriented

metal. You still have those same conditions in the deposit. You still have grain and boundaries. I think that you have the original influence and then the deposit immediately on top of the basis metal is influenced to some extent by the original, and then the next one in influenced by the first deposit. It is a continuous trend until you get to the point where the deposit has an equilibrium with the natural tendency for the solution to plate under those conditions.

For instance, suppose we start with a large-grained piece, as Dr. Blum pointed out there, and the equilibrium tendency is for a grain represented by this equilibrium. Then immediately here we have a slight tendency toward this equilibrium. (Illustrating) The closer we get to the equilibrium the less is required to bring the deposit to that equilibrium. Then eventually there is no force to throw it away from there.

DR. A. K. GRAHAM (Pennsylvania): Just as a means of provoking further discussion of your point, I should like to ask whether this might not be an explanation of some of the things you are referring to. In the first place, you said you were plating at a current density of five amperes per square foot. Byron Hogaboom in his work on polarization in silver was using the individual exploratory electrode at points on a flat silver surface, and, as you know, over a flat silver surface or any flat surface you will have quite a variation in the local polarization value or, let us say, the local current density. But he found that to get any sort of a steady reading at any point that he might be measuring this value, he had to have a current density average which was something under three amperes per square foot, I think. In other words, as you measure the polarization here in the Blum and Haring box with agitation, you are getting an average effect on your surface which is balanced out for any thick setting of your current on your sell. If you are taking an individual electrode, then you get variations at a point which might represent differences associated with the ordinary production currents of your electrolyte.

DELEGATE WOOD: I recognized that in drawing the conclusion. I am familiar with that paper. In fact, I used it rather too much. The average of all their readings very closely

approximates the Haring cell reading. Your safe cell type can only cover perhaps an eighth of an inch circle. You can not get much under that. From a microscopic point of view that is a large area. It would be better to take an average of a larger surface.

By the way, with this agitation that I have spoken of, we found that there was a limiting maximum beyond which more agitation caused no further change in polarization, and we used that as a standard of agitation because it gave us something that we could depend on for reproducibility. With the half cell and the still solution, in fact with the Haring cell and still solution it is hopeless to try to get equilibrium readings.

DR. GRAHAM: I am not offering this evidence in answer to your query about the structure you get under these conditions. I offer it, first, to point out that we know that locally if we use the exploratory electrode that there are variations. You do not have a constant effect unless you have a relatively low current density where your polarization effect is going to be fairly steady. This method of measuring particularly with the higher current density per square foot gives you an average effect under any conditions.

You admit there is a variation. If that is definitely so, let us take this as an oblique bowl that is deep. You are going to plate down in there, we will say. We know that locally at any area across here (illustrating) we can have variations in the current density. That is reflected by our throwing power and by our current density. That variation from this area to that area is also directly related to the polarization of this area and that area. If the structure of the deposit is dependent upon that polarization, it stands to reason, as you have a variation in local current density going down into that bowl, you have a variation in the individual local polarization, and it is possible that your conception of a certain limiting range of polarization gives you a certain recognized structure. At any rate, it could explain a variation in structure as you go into a bowl which might manifest itself as rings or bright or dull plate. I do not know.

DELEGATE WOOD: My point in mentioning the stripes was because you would expect a gradual transition from any one

character of deposit to any other. Here you have a grading of polarization. Why should we not have a uniform grading if this is a uniform grading of polarization; why should we not have a uniform grading of structure, too?

DR. GRAHAM: I would offer as a point for argument of your very interesting paper the fact that we know we have variations over such a surface. There are variations in polarizations, and variations in current density which will be expected to change somewhat in the structure.

In answer to another point that you made, as to the actual cathode potential of one part of that silver deposit and another being greatly different, just due to the silver itself, I think the order of magnitude of such differences is extremely small. The order of magnitude of such differences, the electro-chemical ones, such as these, are, in proportion, very large, and if there is any noticeable difference in structure, I would want to explain it on an electrochemical basis rather than on the initial structure of the plate after it is built up with silver. I am not trying to contradict your ideas but I can not quite reconcile myself to them.

DELEGATE WOOD: I should like to say a word more on that, then. I have read Dr. Blum's statement of 1924. I think that differences between fine grain and coarse grain metal, static potential, rarely exceed .03 or .04 volts, which I think is what you are pointing out now. I certainly am not going to disagree with that, because I have no measurements to go on anyway. My only contention is, and you are supporting it in pointing out Mr. Hogaboom's contention, that if we are measuring an average when we measure anything with a Haring cell, we are also measuring an average when we measure it with a half cell with a drawn-out type. When we start talking about microscopic areas, your half cell reading then simply becomes a reading on a matter of half a dozen grains and some boundary instead of on areas which may be varing due to concentration effects.

I have every reason to believe I have eliminated concentration effects with this agitation that I am using. Perhaps not, but I think so. I can not find anything in the figures which shows that there may be any concentration present. Mr. Hogaboom gave the readings; I think there were about nine readings on a Haring

cell cathode and then they showed the average which was very close to the Haring cell reading. If the Haring cell can average up nine half cell readings, it certainly can average up a half million individual crystal readings, and if the Haring cell reading is an average, so may the half cell reading be, and if it is, then when you take a static potential reading on an area, whether it is fine-grained or coarse-grained, you may still be reading the average. There is no reason why the average has to change greatly because the individual potentials do. You may still have differences in the order of a tenth or two-tenths of a volt and have an average varying only by .01 or .02.

DR. GRAHAM: May I add just one comment in reply to that? I will grant you that in the Haring cell operated as you have defined it, you undoubtedly get a very excellent reading. I dare say the extremes in any point or corner of your small cathode would be relatively narrow, but when you try to interpret that data, or apply that data, the interpretation of variation in structures in the bottom of a quart-size coffee pot, or something of that kind, the variations between the lip and the depth or the bottom of that vessel under actual plating conditions, as far as current and polarizations are concerned, are quite large and you are not dealing with exactly the same thing that you are dealing with in the cell.

DELEGATE WOOD: I tried to say that, Dr. Graham. I only said that it might be possible to interpret this curve from the fact that we know that throwing power varies with these counter E. M. F.'s that we can measure, that we do know about. If you are going to question the accuracy of the measurement, let us drop this one and go back to the other figure in which with a rise in current density or immediately after increasing the current density, polarization decreased. That can not be a concentration effect, and, conversely, when we put the current density down, polarization increased, which also can not be a concentration effect. I do not feel I have proved anything here, but I think there may be something worth thinking about. I do not want to take any more time to urge my contention on you.

DELEGATE WALTER MEYER: In a study of this kind you are apt to confuse macroscopic with microscopic. Macroscopic

effects are geometrical effects and microscopic effects are crystalline effects. They are separate and different. I hope to show you the clear-cut differences between those effects. When a basis metal, such as copper, is etched and copper is deposited upon it, and an extension of the crystal structure up to a certain limiting current density is obtained, we have determined that current density to be of the order of ten amperes per square foot. Above that current density the crystals will change from oriented crystals to random crystals with no definite orientation, and so this question that you talked about, whether you would get extension or not, is dependent upon the current density that is used, and it can be overcome by using complex ion solutions, by colloids, and by changing the current density.

DELEGATE WOOD: In other words, by things which will improve throwing power. That is my only contention.

DELEGATE WALTER MEYER: Which will cut down the crystal size.

MR. T. A. REARDON (Lynn, Mass.): In connection with this bowl that you speak of, did you notice any consistent change in the grain structure as you went down toward the bottom of the bowl?

DELEGATE WOOD: May I ask if you mean a uniform rate of change?

MR. REARDON: Yes.

DELEGATE WOOD: No. I tried to point out that the changes in bands, which I do not profess to understand — by the way, I have made no microscopic examination of that; I am talking macroscopically entirely — just as if you were to take a piece of chalk this way and make a band, and then there will be another one here with a little different appearance, and then perhaps another one, but very definitely tied up with the distance from the lip of the bowl.

MR. F. C. MESLE (Sherrill, N. Y.): I do not know whether or not I understand the problem, but as I see it, in the first place let us assume that this shape here is the same thickness of metal. Therefore, the crystal structure is the same on the outside as on the inside. You overcome any tendency to duplicate the crystal on the outside but it does seem to grow on the inside. Is that

correct? Therefore, the problem is not one of the crystal structure of the base metal. The problem is one of getting enough current in here to plate inside the same as on the outside. That is correct, is it not?

So it seems to eliminate the problem that the phenomena we speak of is not necessarily due to the structure of the article you are plating. Of course, you may have an average of ten amperes per square foot on this piece on the outside and right in here perhaps you would not have one ampere per square foot. That is about the relation you would get, depending upon how deep the pot is. As I see it, the problem is altogether one of getting the current on the inside, and when that is done, the deposit does not follow the structure of the base metal. As the question of why it might be brighter here, as you say, sometimes brighter here and whiter in there and then bright at the end, would you get that when you have agitation on the inside of the pot?

DELEGATE WOOD: I did not cite that. Ordinarily we would not have much agitation on the inside of a pot. In fact, if you do, it does not do any good.

MR. MESLE: For instance, the finer grain structure is the result of high current density, and as your current density is less and less, the tendency is to be white if the solution remains the same, but down in the depth your solution becomes impoverished in silver; therefore, a lower current density will still produce a brighter plate there than it will here where the solution is not so impoverished.

DELEGATE WOOD: Mr. Mesle, I did not bring up the bands to discuss their micro-character, and I do not feel in a position to do so. I do not know anything about the micro structure on the inside of that piece. All I said was that the fact that it occurred in bands instead of a uniform grading seemed to tie up with this fact; that you get quick equilibrium up to a point and then it takes time to come to equilibrium at some definite point and then it would go on arriving at equilibrium quickly, which I take to mean your polarization can vary over quite a wide range for a definite character of deposit, and then to get from that character to another one, after you get from that character to another one, your polarization may vary over another wide range.

Observations *on the* Plating *of* Non-Ferrous Metals *for Outdoor Exposure Tests**

I. INTRODUCTION

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Read at Cleveland Convention 1936

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DURING April and May, 1936, exposure tests were started of the plated specimens, chiefly non-ferrous, that were prepared at the National Bureau of Standards during the preceding fifteen months. The composition of each base metal and the composition and thickness of each coating have been enumerated in the report of the Joint Committee of the A. E. S. and the A. S. T. M. that has planned this investigation. Their report will be included in the A. E. S. Convention Proceedings.

The present paper will be confined to the methods used and the conditions maintained in the preparation and plating of the specimens. In general, the program followed closely the mimeographed outline dated October 29, 1934. The changes made have been based either upon the advice of members of the Joint Committee and other interested persons, or upon the experiences actually encountered in carrying out the program. While the prime purpose of the investigation is to determine the relative protective value of the various coatings, it is obvious that before exposure, the coatings should have a good apearance and be free from any visible defects such as pits, streaks, blisters or peeling. The conditions selected yielded deposits that appeared good before exposure. It was found necessary to omit certain coatings that were originally planned, which proved unsatisfactory under the conditions tried, even though more extensive study might have yielded more satisfactory deposits. It should be noted that the inclusion of any specified procedure is no evi-

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dence that it leads to good protective value. The latter can be determined only by exposure tests such as are in progress.

There were 49 sets of copper, brass, and nickel-brass (so-called "nickel-silver"), and 34 sets of zinc and zinc-base die castings. In order to correlate the observations on non-ferrous metals with the previous studies of coatings on steel, 20 sets of different kinds of steel and cast iron specimens were included. The methods of preparation and plating will be considered in relation to these three groups of base metals.

II. COATINGS ON IRON AND STEEL

1. *Preparation*:

The methods for both the preparation and plating of the strip steel were practically identical with those used in the previous investigation and described in Research Paper 712.* The electrolytic cleaner had the following composition:

Solution A. Electrolytic Cleaner for Steel and Iron.

	N	*g/l*	*oz/gal*
Sodium carbonate, Na_2CO_3	0.6	30	4
Trisodium phosphate, $Na_3PO_4.12H_2O$	0.25	30	4
Liquid soap	.....	0.1	0.01

The cleaning cycle for the strip steel was the same as described in R. P. 712. For the spring steel, the following cycle was used:

CYCLE I

(1) Remove grease with carbon tetrachloride.
(2) Clean cathodically in Solution A at 90°C (194°F) and 5 amp/dm^2 (47 amp/ft^2) for 5 minutes.
(3) Rinse in hot water.
(4) Rinse in cold water.
(5) Swab with cleaning solution A.
(6) Rinse in hot water.
(7) Rinse in cold water.
(8) Dip in 2 N hydrochloric acid (20% by volume) at room temperature for 15 seconds.
(9) Rinse in cold water.
(10) Dip in a solution containing 30 g/l or 4 oz/gal of sodium cyanide
(11) Rinse in cold water.

Steps (10) and (11) were included only before depositing copper from the cyanide bath, and were omitted when nickel was deposited directly on the steel.

For preparing cast iron, the cycle was very similar to Cycle I with the following exceptions: Instead of step (5), the iron was scrubbed with pumice. Instead of step (8), pickling was done in 2 N sulphuric acid (8 fl. oz/gal) at 50°C) for 10 seconds on gray iron and for 8 seconds on malleable iron. After rinsing, the iron was scrubbed with pumice and water to remove any graphite left by the pickling process. Steps (10) and (11) were then followed, because copper was to be deposited on all the cast iron specimens.

2. *Plating*:

The solutions and conditions used for plating on iron and steel were as follows:

(a) Nickel Plating — The rolled nickel anodes, which contained over 99 per cent of nickel, were inclosed in muslin bags. The pH measurements were made with a quinhydrone electrode; hence the recorded values are about 0.5 pH lower than "uncorrected colorimetric" results.

Solution B. Nickel Bath

	N	*g/l*	*oz/gal*
Nickel sulphate, $NiSO_4.7H_2O$	1.4	200	27
Nickel chloride, $NiCl_2.6H_2O$	0.4	45	6
Boric acid, H_3BO_3	0.5(M)	30	4
pH = 5.3			

Three sets of conditions were used.

(1) "Standard."
Temperature = 35°C (95°F)
Current Density = 2 amp/dm^2, (19 amp/ft^2)

(2) With air agitation.
Temperature = 50°C (122°F)
Current Density = 4 amp/dm^2 (37 amp/ft^2)

(3) At a "low pH".
pH = 2.5
Temperature = 60°C (140°F)
Current density = 4 amp/dm^2 (37 amp/ft^2)

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*J. Research N. B. S. **13**, 331 (1934).

(b) Copper Plating — Rolled copper anodes were used in both the acid and cyanide baths, which had the following compositions.

Solution C. Acid Copper Bath

	N	*g/l*	*oz/gal*
Copper sulphate, $CuSO_4.5H_2O$	2	250	33
Sulphuric acid, H_2SO_4	1.5	75	10

Temperature = 35°C (95°F)
Current density = 2.5 amp/dm^2 (23 amp/ft^2)

Solution D. Cyanide Copper Bath

	N	*g/l*	*oz/gal*
Copper cyanide, CuCN	0.25	22.5	3
Total Sodium cyanide, NaCN	0.65	34	4.5
Free sodium cyanide, NaCN	0.15	7.5	1
Sodium carbonate, Na_2CO_3	0.30	15	2

Temperature = 50°C (122°F)
Current Density = 1.5 amp/dm^2 (14 amp/ft^2)

(c) Chromium Plating — Anodes containing 6 per cent of antimony and 94 per cent of lead were used in the following solution:

Solution E. Chromium Plating Bath

	N	*g/l*	*oz/gal*
Chromic acid, CrO_3	2.5	250	33
Sulphuric acid, H_2SO_4	0.05($\underline{N}$)	2.5	0.33

Standard Temperature = 45°C (113°F)
Standard Current Density = 16 amp/dm^2 (150 amp/ft^2)

(d) Observations — No difficulty was experienced in applying the above procedures to the cold-rolled steel and to the spring steel. One set of cold-rolled steel (S 175) was plated with nickel from a solution that was agitated with air and was continuously filtered. These conditions are used extensively in Europe, and permit relatively high current densities to be employed. It was found that there is less tendency for pitting when air agitation is used.

Some study was required to define the best conditions for pickling cast iron to produce sufficient etching and yet not leave an excess of graphite on the surface. It was very difficult to get nickel to adhere well to cast iron, and there was a marked tendency of the nickel to be pitted. For these reasons, an initial

layer of copper was applied from the cyanide bath, either as a "flash" (0.00005 inch) or as a thick layer (0.001 inch). Adhesion tests by Jacquet's method showed that the adhesion of the nickel to cast iron was improved by the introduction of the copper layer, but at best it was much inferior to the adhesion of nickel to steel or brass.

III. COATINGS ON COPPER AND BRASS

1. *Preparation*:

The usual cleaning cycle for copper and brass was as follows:

CYCLE II.

(1) Remove grease with carbon tetrachloride.
(2) Clean cathodically in Solution A-1 at 90°C (194°F) and 3.5 amp/dm^2 (32 amp/ft^2) for 5 minutes.

Solution A-1. Cleaning Solution for Copper and Brass.

	N	*g/l*	*oz/gal*
Sodium carbonate, Na_2CO_3	0.3	15	2
Trisodium phosphate, $Na_3PO_4.12H_2O$	0.12	15	2
Sodium metasilicate, $Na_2SiO_3.5H_2O$	0.07	7.5	1
Liquid soap	.....	0.1	0.01

(3) Rinse in hot water.
(4) Rinse in cold water.
(5) Swab with a solution containing 30 g/l (4 oz/gal) of sodium cyanide.
(6) Rinse in cold water.
(7) Dip in N hydrochloric acid (10 per cent by volume) at room temperature for 10 seconds.
(8) Rinse in cold water.

Some sets were anodically etched in order to determine whether the improved adherence reported by Hothersall would increase the protective value. An acidified ammonium citrate etching solution was prepared by the method used by Hothersall. Citric acid ($C_6H_8O_7.H_2O$) equivalent to 50 g/l (6.7 oz/gal) was dissolved in water and neutralized with ammonium hydroxide. An addition of 20 g/l of citric acid was then made, and the solution was

diluted to the desired volume. The etching was done at room temperature, and an anodic current density of 1 amp/dm^2 (9 amp/ft^2), was applied for 1 minute. When specified, this treatment was substituted for step (7) in Cycle II.

For some sets, anodic etching was conducted in N sulphuric acid (4 fl. oz/gal), with a current density of 1 amp/dm^2 (9amp/ft^2) for about 2 seconds. Even this short treatment sometimes left a dark film on the surface, which was therefore swabbed and rinsed before being plated.

The nickel-brass was prepared for nickel plating according to Cycle II., except that in step (5), scrubbing with pumice was substituted for the swabbing. When chromium was to be deposited directly on the nickel brass, in step (7) the metal was dipped in 2 N sulphuric acid instead of in N hydrochloric acid.

2. *Plating*:

The solutions and conditions used for depositing copper, nickel, and chromium on copper and brass were the same as those listed above for iron and steel.

3. *Observations*:

Very little difficulty was experienced in getting good, adherent deposits on copper and brass. It remains to be seen whether the anodic etching of the brass has improved the adherence or the protective value. The ammonium citrate solution produces good etching, but is somewhat troublesome to prepare, and is decomposed by mold growths. The sulphuric acid etching solution is easy to prepare and is stable, but it acts too quickly and tends to leave a film. Further study would probably lead to a more satisfactory solution for the anodic etching of brass.

IV. COATINGS ON ROLLED ZINC AND ON ZINC-BASE DIE-CASTINGS

The following procedures were used for the preparation and plating of the rolled zinc, for die casting A.S.T.M. No. XXI, which contains about 3% of copper, 4% of aluminum, and about

0.03% of magnesium, and for die-casting A.S.T.M. No. XXIII, which contains 4% of aluminum, and about 0.04% of magnesium.

1. *Preparation*:

The following cycle was used for preparing the zinc and die-castings.

CYCLE III.

(1) Remove grease with carbon tetrachloride.

(2) Clean cathodically for 1 minute in solution A-Z (which contained 45 g/l (6 oz/gal) of trisodium phosphate ($Na_3PO_4.12H_2O$)) at 90°C (194°F), and about 2.5 amp/dm^2 (23 amp/ft^2).

(3) Rinse in hot water.

(4) Rinse in cold water.

(5) Dip in 0.5 N hydrochloric acid (5 per cent by volume) at room temperature, until effervescence just starts over the entire surface. For rolled zinc this required approximately 2 seconds; for die-casting XXI, 3 seconds; and for die-casting XXIII, 5 seconds.

(6) Rinse in cold water.

2. *Plating*:

(a) Nickel Plating — The high-sulphate bath had the following composition:

Solution G. High-Sulphate Nickel Bath

	N	*g/l*	*oz/gal*
Nickel sulphate, $NiSO_4.7H_2O$	0.5	75	10
Sodium sulphate, Na_2SO_4 (anhydrous)	1.5	110	15
Ammonium chloride, NH_4Cl	0.25	15	2
Boric acid, H_3BO_3	0.25(M)	15	2
pH = 55			

The following conditions were employed:
Temperature N 22°C (72°F)
Current Density N

(a) For the strike deposit (1 minute) 4 amp/dm^2 amp/ft^2).

(b) For the balance of the high-sulphate deposits, 1 amp/-dm^2 (9 amp/ft^2).

The cathode rod was moved back and forth longitudinally with a speed of about 7 ft/min. For the "standard" nickel bath, Solution B (page 84) was employed, with a moving cathode rod. The temperature was 40°C (104°F). For plating over a copper layer, the current density was 4 amp/dm^2 (37 amp/ft^2); and over a high sulphate nickel layer, the current density was 5 amp/dm^2 (48 amp/ft^2).

(6) Copper Plating — The cyanide bath, Solution D (page 84) was used under the same conditions as those employed on steel and brass.

(c) Chromium Plating — Solution E (page 84) was used for the chromium plating. For depositing on buffed nickel, the conditions were the same as on nickel over steel and brass. For depositing directly on the zinc, the "hot" bath was operated at 45°C (113°F) and 18 amp/dm^2 (170 amp/ft^2). The "cold" bath was used at 30°C (86°F) and 10 amp/dm^2 (93 amp/ft^2). Both the hot and cold deposits on zinc and die-castings were dull and required buffing.

3. *Observations*:

The preparation and plating of zinc and zinc-base alloys require special procedures, because zinc is readily attacked by both acid and alkaline solutions, and because it displaces nickel, in the form of a black powder, from the ordinary nickel plating solutions. It is therefore necessary to select conditions for preparation and for plating that will counteract these tendencies. An initial coating of nickel must be applied from a solution such as the high sulphate bath, in which the zinc does not readily deposit nickel by immersion. If thicker deposits than 0.0003″ are required, it is customary either to deposit additional nickel from a standard bath after the initial nickel, that is, to use a "duplex" nickel coating, or else to deposit copper first, from a cyanide bath, followed by nickel from a standard bath. In either case, chromium is applied over the final nickel.

In working out the detailed procedures for producing these coatings, valuable assistance was received from C. E. Reinhardt of the New Jersey Zinc Company, the firm that cooperated in preparing the die-castings that were made especially for this investigation. The casting of flat die-cast specimens is difficult, and their plating involves some problems that may not be encountered on more complicated shapes. For example, it is very difficult to design the racks in such a way that no black or bright streaks will originate from unplated zinc at the contacts on the edges. This difficulty was largely overcome by making the contact points small and unshielded.

In plating on zinc from a high sulphate solution, it is necessary to use a fairly high current density (a "strike") for a short time if the articles are of very complicated shapes, or if, as in this case, an appreciable area on the edges is shielded by the rack and contacts in spite of the improved contacts. For plating many commercial articles in a high-sulphate bath, a strike is unnecessary. In plating nickel from the "standard" bath over an initial nickel or copper deposit, a high current density is desirable to counteract the tendency of zinc to dissolve wherever any pores may exist in the initial deposit. But the use of high average current densities tends to produce burning at edges or corners where still higher current densities prevail. This tendency may be overcome by moving the cathodes, for example by oscillating the cathode rods, which was done in both the high-sulphate and the "standard" nickel baths.

Under the conditions finally adopted, apparently satisfactory deposits were obtained in the high-sulphate bath up to thicknesses of 0.001 inch. It remains to be seen whether the greater brittleness of such coatings will lead to failure on exposure. The duplex nickel deposits were generally good. Considerable blistering was encountered with those coatings that included a layer of copper, either directly on the zinc, or between an initial and a final nickel layer. This blistering occurred in the copper layer, whether or not the subsequent nickel layer had been applied. It usually

appeared in from 6 to 24 hours, and was so marked with certain thicknesses of copper and nickel that those sets had to be discarded. There was no apparent connection between the blistering and the free cyanide content of the copper bath, or the temperature or current density. It was more pronounced with alloy XXIII, which contains only zinc and aluminum, than with alloy XXI, which contains zinc, copper, and aluminum. Further study would be required to determine whether this difference was caused by the composition of the alloys or by the conditions used in casting them. There is room for much study of the cause and remedy of these blisters in the copper layers.

V. GENERAL OBSERVATIONS

Certain of the difficulties encountered arose from the limited scale of operations and can be readily avoided in large scale production. It was found that the largest single source of defective plating was the contamination of the cleaning solution, which was best overcome by the frequent preparation of new solutions. The cleaning of brass is likely to introduce some lead, zinc, and tin into the cleaner, and to cause their deposition as a scum on the cathodic plates. If, as sometimes recommended, a momemtarily reversed current is used to remove this scum, it may lead to further attack of the brass, and thus increase the contamination of the cleaner.

A still more elusive source of trouble was the introduction into the cleaner of traces of chromic acid from racks used in chromium plating. This may lead to poor adhesion and subsequent peeling of the deposits, even though no visible film remains on the metal after the cleaning process. For this reason it is essential to have a separate tank for cleaning the racks and specimens to be chromium plated.

It was very important to define and control the conditions for pickling and acid-dipping. All the base metals used in this program had a good finish on one side, and there was therefore no need of acid treatments to remove visible scale or rust. The purposes of the acid dipping or electrolytic etching were (1) to remove any traces of alkali remaining from the preceding clean-

ing process, (2) to remove any very thin films of oxides or other compounds from the metal surface, and (3) to produce just sufficient etching to increase the adhesion, but not enough to cause rough deposits that require excessive buffing. The conditions for etching varied with each base metal, and had to be carefully controlled. In general it was preferable to etch rapidly, as then the attack was more uniform than in slow etching. However, the time had to be more carefully controlled in the rapid etching.

It was found more difficult to produce uniformly bright chromium deposits on nickel surfaces that had stood for several days after buffing than on freshly buffed surfaces. This behavior may be caused by increased passivity of the nickel, or by slight action on the buffing greases on the nickel. To avoid this difficulty, the specimens were plated with chromium soon after the nickel was buffed.

The author wishes to express his appreciation, as well as that of the American Electro-Platers' Society, to his assistant, Mr. C. K. Fewell, and to his associates at the National Bureau of Standards for their assistance in the plating of these specimens; to Dr. Wm. Blum for his advice and assistance, and to members of the Research Committee and many others who furnished helpful information. (Applause).

PRESIDENT SLATTERY: Is there some discussion of Mr. Strausser's paper?

MR. G. SODERBERG (Detroit, Mich.): I just want to make one comment on this anodic etching. We have had a little experience with it in studying anodic conditions and I have quite definitely reached the conclusion that formations of black scums and films have to do with the solubility of the impurities in that base metal in the etching agent in question, and often by adding something else to the bath in which that material is soluble you can very easily get around those difficulties in anodic etching. Possibly you have been working along those lines too.

Notes on the Rapid Electrodeposition *of* Iron

By C. KASPER

Read at Cleveland Convention 1936

1. INTRODUCTION

DURING the past year experiments have been made on a semi-commercial scale at the U. S. Bureau of Engraving and Printing upon the rapid deposition of iron, with special reference to the production of printing plates. The conditions that were found to be favorable for rapidly depositing smooth, dense, ductile iron plates are limited and require careful control. Consequently very rapid deposition is not likely to be used for the above purpose except when speed of production is important, for example in making the initial "altos" and printing plates for a new series of notes.

In connection with the above experiments, the structure, hardness, tensile strength and ductility of typical specimens were studied. These results and other details of the research will be published at the conclusion of the investigation. The purpose of this brief paper is to summarize the properties of rapidly deposited iron and their relation to the conditions of deposition. It is hoped that this information will be useful to those few persons who are engaged in iron deposition, and that in addition it may serve to illustrate certain general principles of electrodeposition.

II. CONDITIONS USED IN THE DEPOSITION AND TESTING

The solutions all contained ferrous chloride, $FeCl_2.4H_2O$, in concentrations from 3 to 6N (40 to 80 oz/gal). In a few cases, calcium chloride or boric acid was added. All the solutions were slightly acid, corresponding to from 0.05 to 0.25 N hydrochloric acid (0.3 to 1.2 avoir. oz/gal HCl, or 0.7 to 2.8 fl. oz/gal of concentrated hydrochloric acid, with a specific gravity of 1.18). All the solutions were heated to from 194 to 226°F. (The high concentration of salts raised the boiling point above 212°F).

The anodes, which were rolled Armco iron plates, were surrounded with asbestos bags. At high current densities great care

must be used to prevent the passage of even very fine solid particles from the anode to the cathode, where they are likely to cause extreme roughness. A special grade of blue asbestos cloth was required for this purpose.

The deposits were made at current densities from 100 to 300 amp/ft^2 upon flat steel plates, 4 x 10 inches. The surface of the steel was treated with graphite to facilitate separation of the subsequent deposit. A layer of nickel about 0.001 inch thick was then deposited, followed by iron to the desired thickness, usually about 0.035 inch. Each deposit that was stripped off and tested therefore consisted of about 3% nickel and 97% of iron. No correction was made for the small effect of this nickel layer on the tensile strength or elongation. The hardness measurements were made directly on the deposited iron. The tensile strength and elongation were measured on strips with a reduced section 0.5 inch wide. The exact thickness of each was measured and used in the computations.

III. CONCLUSIONS

The principal changes in the conditions generally used for depositing iron in order to produce good deposits at current densities of 200 to 300 amp/ft^2 are to increase (a) the concentration of ferrous chloride; (b) the acidity; and (c) the temperature. The effects of such changes upon the structure and properties of the deposits may be summarized as follows:

(a) *Concentration of Ferrous Chloride* — An increase from the customary value of 3 N (40 oz/gal) to 5 N (67 oz/gal) favors the production of ductile iron at high current densities, but a further increase has little additional effect.

(b) *Acidity* — In general an increase in acidity increases the ductility of the deposits. For example, at 200 amp/ft^2 and 212°F, increasing the acidity from 0.04 to 0.10 N reduced the tensile strength from 109,000 to 83,000 lb/in^2, increased the elongation from practically zero to 13 per cent, and lowered the Brinell number from 228 to 182. If, however, the current density was increased to 300 amp/ft^2, it was necessary to increase the acidity to about 0.15 N to produce ductile iron. As a first approximation,

the optimum acidity must be changed in proportion to the current density.

(c) *Temperature* — Even small changes in temperature in the range between 190° F and 230°F have relatively large effects on the ductility. In general, at a given current density, an elevation in temperature produced softer deposits. This is well illustrated in Table 1.

Table 1

Effect of Temperature at 200 amp/ft^2.

Expt.	*Temperature*		*Tensile Strength*	*Elongation*	*Brinell Number*
	°C	*°F*	*lb/in^2*	*%*	
A-6	95	203	113,000	4	210
A-5	100	212	82,000	13	182
A-10	106	223	72,000	16	150

(d) *Additions to the Bath* — Relatively large concentrations of calcium chloride or of boric acid have very little effect on the properties of the iron.

(e) *Relation Between Properties and Structure* — In general, hard, brittle deposits of iron are finer-grained than the soft ductile deposits. The fact that the hardness is increased by lowering the acidity or the temperature, or by increasing the current density, is consistent with the general opinion that the hardness is associated with the inclusion of oxides or other foreign material. Efforts will be made to confirm this assumption.

Acknowledgments of the author are made to C. T. Thomas of the Bureau of Engraving and Printing for assistance in the deposition experiments, and to his associates at the National Bureau of Standards for assistance in the physical and metallographic examinations. (Applause)

THE 1937 CONVENTION

OF THE A. E. S.

THE 25TH

ANNUAL CONVENTION

THE SILVER JUBILEE

at New York

June 14th, 15th, 16th and 17th

at the Hotel Pennsylvania

Directly opposite the Pennsylvania R. R. Station in New York City.

After twenty-five years we'll be glad to have you home again where the Society was founded. We hope to welcome you all.

For all information — write to :

FRANKLYN J. MACSTOKER, General Chairman
25 Princeton Street, Garden City, N. Y.

or

the Committee Chairman named below:

Publicity Committee—Louis H. Cates
645 Ocean Parkway, Brooklyn, N. Y.

Programme Committee—Ralph J. Liguori
2429 Hubbard Street, Brooklyn, N. Y.

Educational Committee—John J. Rolff
117-30 168th Street, Jamaica, N. Y.

PROGRESS REPORT
EXPOSURE TESTS OF ELECTROPLATING ON NON-FERROUS METALS

During the spring of 1936, several thousand specimens, chiefly of plated copper, brass, zinc, and die castings, with some steel and cast iron, were exposed in six locations. They have been inspected at least twice at each place. The attendance and the interest shown in these inspections have been very gratifying. The purpose of this report is not to state any conclusions, which might be premature, but rather to describe the steps that are being taken to reach sound conclusions regarding the value of plated coatings.

It will be recalled that for rating the coatings on steel, a scale from 5 to 0 was used, based upon the percentage of rust present. This scale proved satisfactory, and has been retained in the inspection of the new steel and cast iron specimens.

As it was difficult to predict what types of failure might occur on various other base metals, the numerical scale was not at first applied to them. Instead, each inspector recorded the appearance of the specimens, the types of failure observed, and the approximate extent (in percent of the area) of such defects. Study of these observations showed that in industrial locations dark stains appeared on plated copper and brass. On zinc and die-castings, white stains appeared on some specimens. In addition cracks and blisters developed in some of the coatings. In milder locations most of the coatings are practically perfect.

In the compilation of results, and the quantitative comparison of different coatings, a numerical scale is very helpful. It was found that when the above descriptive observations were expressed on the numerical scale used for steel, but in this case including any major defects, the results were consistent with the thicknesses of the coatings. In the second inspections, numerical ratings were therefore assigned by each inspector. Longer periods will be required before valid conclusions can be drawn from these observations.

In the previous investigation of coatings on steel, it was recognized that the results of continuous exposure did not necessarily show the relative value of the coatings under service conditions that included cleaning and care of the plated parts. In order to obtain information on the effects of such treatments, a few of the badly tarnished specimens were cleaned by polishing with mild abrasives, which practically restored the original luster of the chromium finish. In addition, a few of the cleaned coatings were treated with grease or wax (such as is commonly applied to exposed plated parts) in order to learn whether such treatments add to the protective value of the coatings under severe conditions. If a decided improvement is noted, a systematic study of such effects will be included in the investigation.

Color photography has been suggested as a means of recording the appearance of the specimens at successive intervals, and thus assisting in the comparison of various specimens in different locations. Through the generous cooperation of several persons and firms, a number of color photographs of the specimens have been made with different types of film and of exposure. The results thus far obtained are promising, though further study will be required to define the conditions for permitting quantitative comparisons of the tarnish and corrosion.

Laboratory studies upon methods of measuring the thickness, distribution, porosity and protective value of these coatings are in progress.

From the above notes it may be seen that the greatest value can be obtained from any such investigation only if continuous efforts are made to apply to it, or to at least try out, new ideas and new methods. The committee is greatly indebted to those persons who have made suggestions, and who have cooperated in the inspections and related activities, and will welcome further comments and criticisms.

Respectfully,

W. BLUM, Chairman,
Joint Inspection Committee
on Non-Ferrous Metals,
A. E. S. & A. S. T. M.

CONVEYORIZED, THREE-DIP DETREX DEGREASER

The large three-dip degreaser illustrated in Fig. 1 is a recent addition to the complete line of standard and special machines manufactured by Detroit Rex Products Company, 13005 Hillview Ave., Detroit, Mich.

This machine, which is designated as Model 3DC-650, consists of three chambers which are separated by two wide overflow dams. It is equipped with a two-strand, cross-rod type conveyor, and a variable speed drive.

The cycle of cleaning operations in this automatic degreasing machine is: first, immersion in boiling solvent; second, immersion in solvent distillate rinse; and third, immersion in pure solvent vapors. The work is placed in baskets which are hung from the conveyor cross rods, and thus conveyed through the machine. The work comes out perfectly dry and clean — ready for subsequent finishing operation.

The steam coils for heating the solvent are located in the first chamber shown at the right end of the machine. An air operated, steam actuated thermostat control is used for automatic temperature regulation.

The machine is completely hooded and designed so that the natural solvent loss is less than 1/2 gallon per hour. The water-jacket condenser completely encircles the machine, and there is a solvent distillate collecting trough inside directly beneath the condenser zone. The motor-driven pump shown in lower left center of photograph transfers the solvent between any chambers desired.

The solvent used in Detrex Degreasers is either Perm-A-Clor or Triad, which are non-inflammable and non-explosive safety solvents.

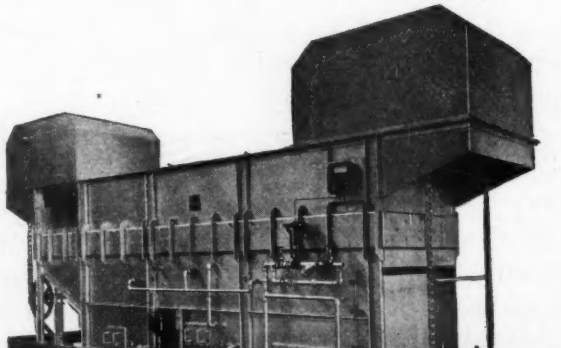


Fig. 1. Automatic, Three-Dip Detrex Degreaser used for the production cleaning of large stampings and deep-drawn parts.

NEW TRADE LITERATURE

Cleaning Processes. An attractive 12-page booklet, entitled "Scientific Metal Cleaning" has just been published by Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, Michigan. This booklet describes in detail the applications and advantages of Detrex Degreasing with Perm-A-Clor or

Triad Safety Solvents, and the applications of Triad Alkali Cleaning Compound and Strippers. It is well illustrated with photographs of various standard and special designs of Detrex Degreasers. These machines are used for the rapid and economical cleaning of metal products prior to finishing, inspection or heat treating. Emphasis is placed upon the expert engineering service and the latest developments in cleaning technique offered by this company.

Degreasing — Trial Offer. A four-page folder just issued by Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, Michigan illustrates three of their standard Detrex Degreasers which are offered for trial in plants desiring to increase the speed and reduce the cost of their cleaning operations. It is also pointed out that a complete line of Alkali Cleaning Compounds and Strippers is manufactured by this company, thus providing a complete service for both kinds of cleaning operations.

Cleaning Before Rust Proofing. The advantages of speed, economy, and most satisfactory cleaning before all kinds of rust proofing and finishing operations is obtained by the Detrex method of Solvent Degreasing, it is pointed out in a leaflet being distributed by Detroit Rex Products Company, 13005 Hillview Avenue, Detroit, MiMhigan. This leaflet is illustrated with several photographs of automatic Detrex Degreasers for the production cleaning of metal products by the use of either Perm-A-Clor or Triad Safety Solvents.

SPECIAL VAPOR-SPRAY-VAPOR DETREX DEGREASER

The line of Degreasers manufactured by Detroit Rex Products Company, 13005 Hillview Ave., Detroit, Mich., has been augmented by the new machine shown in Fig. 1. This is a special Vapor-Spray-Vapor machine equipped with a monorail conveyor. The unit shown has been designed to handle small racked parts such as poppet valves, flat sheets, etc. Hangers are spaced at intervals along this conveyor to carry the work holding racks.

The conveyor is so arranged that the work is lowered into the solvent vapors and passes through pressure sprays of hot clean solvent. After making a horizontal turn around a traction wheel (at the right end of the machine), the conveyor brings the work back through the vapors. Continuing on, the work is elevated, and passes out of the machine at the same end, and at the same elevation as it went in.

Steam coils are placed in the boiling sump (which is shown in the lower left center of Fig. 1) and in the clean solvent distillate collecting chamber (shown at right end of machine). This machine is equipped with an air actuated, steam operated thermostatic control. The boiling sump is equipped with an auxiliary clean-out door to obviate the necessity of removing the steam coils when cleaning out accumulated sludge.

The large header shown at the left of the photograph is a tube-type condenser to augment the supply of clean solvent distillate provided by the water-jacket condenser. A solvent collecting trough is located beneath the water-jacket condenser. All of the distillate flows into the heating chamber at the right end of the degreaser. From here, it is forcepumped directly on to the work. The solvent that drains from the work, as well as the over-flow from the clean solvent heating compartment, flows back into the boiling sump.

For maximum heat economy, this machine is insulated with panelled mineral wool up to the water jacket condenser.

The rated production cleaning capacity of this machine is approximately 6500 small parts per hour at a conveyor speed of 10½ ft. per minute. The overall dimensions of the unit shown are: 20 ft. long, 5 ft. wide, and 9 ft. high.

Fig. 1. Special design of Vapor-Spray-Vapor Detrex Degreaser for cleaning racked parts, sheet metal, etc.

.....

Tear off and mail to:

DETROIT REX PRODUCTS COMPANY
DETROIT, MICHIGAN

DATE.....

We would be pleased to receive:

Halftone Cut No. ..... Glossy Print No. .....

....

Publication.....

Attention.....

Address.....

.....

An Excellent Suggestion

The following letter has been received from Cleveland Branch. Its adoption by other branches of the A.E.S. would provide a lot of interesting and instructive topics at the New York Convention by our members. Papers on Chrome, Cadmium, Copper, Nickel, Zinc, Pickling, Polishing, etc. could be discussed at the Branch meetings for the remaining months previous to the Convention.

In addition to the value of preparing the papers, the suggestion contained in Mr. Carlson's letter should be an incentive to a fuller attendance at the branch meeting each month, as the members would have the privilege of adding their personal contribution to the make-up of the paper.

The problems, and the successful solution of the problems experienced by every foreman plater, would enter into the subject under discussion and thus create an enthusiasm that is often lacking at our branch meetings.

We ask our members to give careful consideration to the suggestion of the Rochester and Cleveland Branches and act at once if your branch decides on a particular subject. In order to simplify matters, each branch should inform the Executive Secretary's office regarding the topic chosen, then if there should happen to be a duplication, the Secretary or Librarian will be notified accordingly, so that another topic may be presented if deemed advisable.

Mr. W. J. R. KENNEDY,
90 Maynard Street,
Springfield, Mass.

Dear Mr. Kennedy:

At the October meeting of the Cleveland Branch it was decided to select a topic for consideration at the Branch meetings and from the study of this topic throughout the year prepare a paper for presentation at the New York Convention.

This idea did not originate with the Cleveland Branch but with Rochester. We are informing you of our plans with the thought in mind that other Branches might wish to make application of the idea in preparing a paper to be read at the 25th Anniversary Convention.

We feel that after studying the data we expect to be able to collect during the year, that we will be in a position to prepare a paper that will do credit to the Cleveland Branch - and that our entire membership will profit by the exhaustive study of one subject.

We are writing the New York Committee advising them of our plans and offering this as a means of obtaining more papers from the Branches than ever before.

Very truly yours,

F. M. CARLSON, *Librarian*,

Cleveland Branch.

Important Meeting of Hartford Branch

The Hartford Branch of the American Electro-Platers' Society is planning to hold a meeting on November 9, 1936 at which Dr. H. H. Harkins of the U. S. Rubber Products Co. will be the principal speaker. His subject is "How Rubber Cuts Corrosion Costs" — (in Manufacturing and Plating operations). There will also be a short address by Mr. Osmond True, also of the U. S. Rubber Products Co., who will describe the benefits gained in existing rubberized installations under the subject "Reaping Rewards with Rubber." Assisting the local branch at this meeting is the Storts Welding Co. of Meriden, Conn. which is connected with the U. S. Rubber Co. in building rubber lined plating equipment.

All those in the plating industry and others interested in the most recent developments of rubber lined equipment are invited to attend this lecture. Hartford Branch is expecting a big turnout and invites representatives from all other New England Branches to attend this interesting and instructive lecture *and demonstration.*

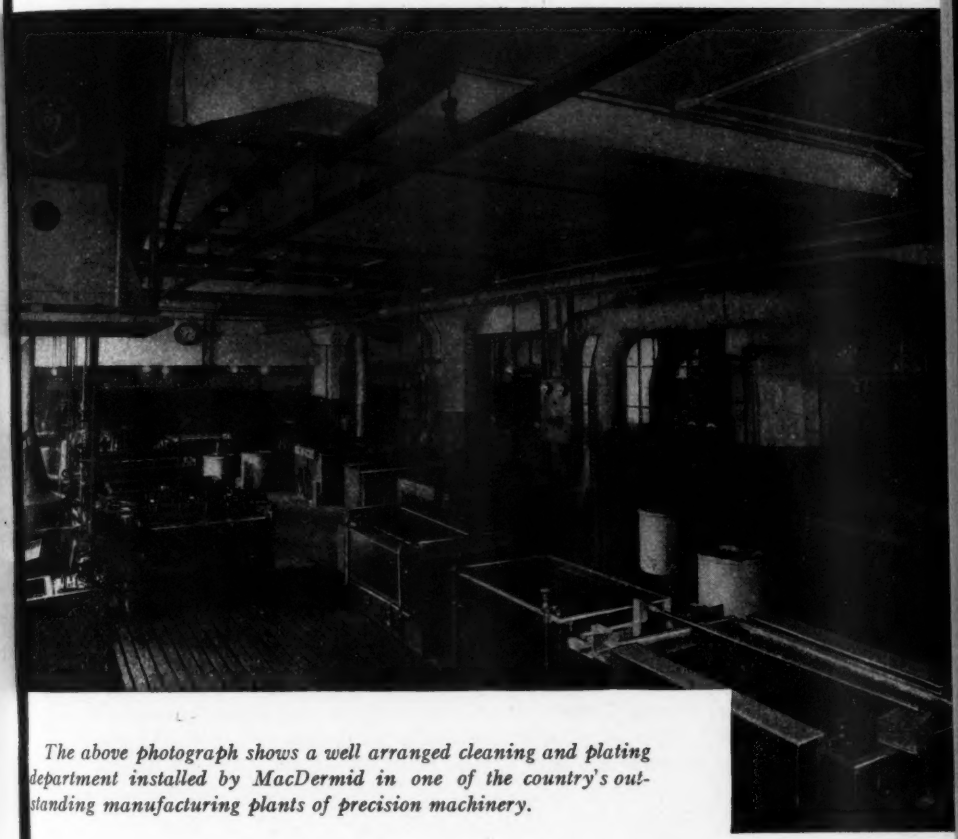
Remember the date — **November 9, 1936**

The Place — **State Trade School, Washington St., Hartford.**

Be sure to come and bring your friends.

It is planned to have a demonstration and also some lantern slides at the meeting.

W. E. Bancroft, *Librarian.*
33 Garfield Road,
West Hartford, Conn.



The above photograph shows a well arranged cleaning and plating department installed by MacDermid in one of the country's outstanding manufacturing plants of precision machinery.

GRADE R, the improved METEX METAL CLEANER

Metex Grade "R" is a cleanser which will take care of all general metal cleaning operations in the average shop.

"Grade R" cannot do *every* job — there are other Metex Cleansers for specific uses — but it is the best *all-around* cleanser we have produced in our wide experience with chemical formulae.

MacDermid Laboratory and Experimental Dep'ts

Constant research has developed and will continue to develop, different and unusual types of basic cleaning material. The MacDermid laboratory and experimental departments are continually investigating these new wetting and penetrating agents so they may be incorporated, whenever feasible, in Metex products for improved cleaning efficiency.

INSPECTION OF PLATED COATINGS

The regular inspection of plated coatings took place at the Bell Telephone Laboratories, 463 West St., New York, Thursday, Sept. 18, and Friday, Sept. 19 at Sandy Hook. The following were present:

W. M. Phillips, Chairman, General Motors Corp.
George B. Hogaboom, Hanson-Van Winkle-Munning Co.
Wm. Blum, Bureau of Standards
C. H. Sample, Bell Telephone Laboratories
C. E. Reinhart, New Jersey Zinc Co.
A. W. Tracy, American Brass Company
W. A. Wesley, International Nickel Co.
E. V. Mott, Western Union Telegraph Co.
B. H. McGar, Chase Brass and Copper Co.
W. E. Baulieu, Bridgeport Brass Co.
Walter R. Meyer, General Electric Co.
G. Byron Hogaboom, Newark, N. J.
Charles J. Mund, Sanitary Brass Institute
R. J. McKay, International Nickel Corp.
H. Vincent Davis, R. & H. Div., Dupont Company
W. J. R. Kennedy, A. E. S.
N. R. Hall, Newark, N. J.

PURICO WONDERBAR AND METAL CLEANERS

The Puritan Manufacturing Co., Waterbury, Conn. has developed a buffing composition, that is pre-saponified so that it washes absolutely clean regardless of the type of work. Unlike many ordinary buffing compounds used on pierced, grooved and filigreed work it cleans easier, will not tarnish the work, saves washing, brushing and scrubbing and reduces rejections and labor costs. It will cut any color the same as any other good tripoli or white composition and is soluble in plain hot water.

Purico Star Metal Cleaner for cleaning before plating. Purico Triumph Metal Cleaner cleans steel and brass. Can also be used for removing Japan, Enamel, Lacquer, Paint etc. and Puritec Metal Cleaner for Aluminum and Zinc are also made by the Puritan Co. Why not give them a trial?

Here and There

There was a lot of interest manifested by those attending the inspection of plated coatings at Bell Telephone Laboratories and Sandy Hook.

It was questionable for a time whether the Inspection at Sandy Hook would be held or not on account of the hurricane. It was a wonderful sight, to behold the sea in all its fury. The inspection was held however although heavy winter overcoats felt extremely comfortable.

Detroit Branch members believe in attending the meetings. There was a good crowd. The papers on Cadmium by Messrs Lindahl and Soderberg were fine. The members are very enthusiastic about the Membership drive. George Nankervis makes an ideal chairman. He's full of pep. Watch the membership grow.

Cleveland Branch is right there when any topic comes up for discussion. This was one of the best meetings we've attended for some time. President Scott, Secretary O'Berg and Librarian Carlson sure know how to make a meeting interesting. Supreme President E. Steen Thompson was present as usual. It was nice to greet all the boys again.

The outdoor picnics are nearly all over but they have been well worth while. Some of the branches are talking of indoor picnics for the winter. We wonder if the ladies are not back of all these Social gatherings. How about a ladies auxiliary of the A.E.S? Why not?

Bob Leather's pictures of the last three conventions should go over big in Boston. Bob's good natured smile gets them all wherever he goes. Don't miss these pictures. They're good.

Visiting Providence a few weeks ago, we met Mr. Tyndall of Claflin and Co., wholesale and retrail drugs. Mr. Tyndall was for many years deeply interested in the local branch. He said many nice things about the Society and many of the members whom he knew in other days.

Pass your copy of the REVIEW to a prospective member sometime. Tell him about the A.E.S. then hand him an application blank. Boost the membership campaign.

The Abstract Section

JAMES W. HANLON, *Chairman, Program and Educational Committee*

METAL CLEANING AND FINISHING

Trends in the Plating Industries — By Dr. C. L. MANTELL—The development, application and appreciation of plating standards continues to receive increasing attention. Zinc offers a permanent challenge to cadmium. In numerous fields it has effectively supplanted cadmium. Bright nickel plating, already well established, continues to expand. Anodic oxidation of aluminum has been extended to new uses. Automatic methods of controlling the process have been developed. Production of metal powders produced electrolytically has increased. The production of coated materials by the application of metal powders to base metals, threatens to compete with electroplating. E. T. SHEEHAN.

Electrogalvanizing of Round Wire — By A. WEISSELBERG, *Wire & Wire Products*, Vol. **11**, June 1936 pp. 281-5—Existing processes for electrogalvanizing are reviewed and compared with hot galvanizing. Operating advantages are (1) maximum Zn economy as no zn losses (2) no losses during shut downs (3) accurate control of thickness of coating (4) cleanliness and sanitary conditions of the plant. Coating is very uniform and a thickness of 0.2 oz/sq. ft. can be obtained in one run. Physical properties of wire are not affected by electrolytic process as they are in hot galvanizing, *especially for springs*! Coating of pure zinc is very ductile. Cost per ton is given as $970. for 0.6 oz./sq. ft. and $13.15 for 1 oz./sq. ft. PHIL J. RITZENTHALER.

Electrolytic Plating of Aluminum in Fused Salt Solution — By S. I. ORLOVA "*Legkie Metallic*" Vol. **4**, Dec. 1935 pp. 9-16 (In Russian)—Best results are obtained by using a chloride solution with a molecular ratio of Al Cl_3 - Na Cl of 2:1 and a current density of 0.2 to 0.5 amp./sq. Dec. at a temperature of 125°C. The Al Cl_3 in the electrolyte is volatile and inferior results are obtained as its concentration decreases. The addition of 0.2% lead chloride to the electrolyte improves the coating. PHIL J. RITZENTHALER.

The Electrodeposition of Bronze Usuing Bronze Anodes — By S. BAEIR and McNAUGHTON — Tech. *Publication of Unternational Tin Research Council*, Series A, No. **27**, 1936—Paper describes results obtained as a part of series of investigation carried on by council. Preliminary work showed that nickel or copper added to a stannate solution as a complex ion could be co-deposited with tin. For deposition of bronze, this bath was found to be superior to the oxalate baths. Paper records result. Solution used had following composition:

Cu Cn	- 150 g/liter
Sodium Stannate	- 50 g/liter
Cyanide	- 15 g/liter

Anodes = 12% Sn cast rods

Bath Temp. = 65°C. Data reported for anode and cathode efficiency. Hot water porosity tests and throwing power are given. It is suggested that excellent throwing power of bronze solution is due to fall of cathode efficiency with increase in current density. Comparative tests were made with chrome plated steel with undercoats of bronze and nickel. Bronze was found equal to nickel for undercoat. PHIL J. RITZENTHALER.

Electro Deposition of Dental Inlay Dies — J. A. Viverits — *Dental Cosmos* — Vol. **22**, Nov. 1935, p. 1202-10—Detailed descriptions are given for producing Cu shell dies for inlays. Surface of wax model is made conducting by application of copper powder after which the copper shell is deposited from sulfate bath using current density of 60 amps./sq. cm. After backing shell with low fusing alloy, stone, or plaster it is ready to use.

PHIL J. RITZENTHALER.

Extract from

BULLETIN

OF THE

British Non-Ferrous Metals Research Association

PUBLISHED AT THE OFFICES OF THE ASSOCIATION,
REGNART BUILDINGS, EUSTON ST., LONDON, N. W. 1.

Issue No. 90 *Dated Aug.-Sept.* 1936 *Page* 35-36.

AMERICAN ELECTRO-PLATERS' SOCIETY. **Proceedings of the Twenty-Fourth Annual Convention of the American Electro-Platers' Society** (June, 1936). 308 pp. Published by the Society, 90, Maynard Street, Springfield, Massachusetts, 1936. $5.

The tasks which confront the American Electro-Platers' Society are much the same as those of our own Electro-depositors' Technical Society. The bulky volume now before us gives a verbatim mimeographed account of the proceedings at this year's annual meeting of the American body. The papers read at these meetings are also published in the Society's *Monthly Review*, but as the space available there is limited, publication of some of the numerous papers is rather long delayed. The issue of the present mimeographed edition, which is complete with photomicrographs where necessary, is therefore very convenient.

The first 67 pages are devoted to the Society's discussion of its domestic affairs, the 24 papers read occupying 241 pages. The papers, some of which

have already been noticed in the appropriate section of this *Bulletin*, are as follows.—"Summary of Studies on Electrodeposition at the National Bureau of Standards" (W. Blum, pp. 68-72); "Report of Joint Committee on Exposure Tests of Plating on Non-Ferrous Metals" (W. Blum, pp. 72-82); "Observations on Plating of Non-Ferrous Metals for Outdoor Exposure Tests" (P. W. C. Strausser, pp. 82-89); "Notes on the Rapid Electro-deposition of Iron" (C. Kasper, pp. 90-92): "Commercial and Practical Aspects of Throwing Power as a Factor in Character of Deposits" (D. Wood, pp. 92-103); "Use of Metal Rectifiers for Electroplating in England" (R. M. Wick, pp. 103-120); "Polishing Grain and Its Application" (F. D. Bowman, pp. 120-123); "Orientive Effects of Geometrical and Crystalline Structure of Basis Cathode on Crystal Structure of Electrodeposits" (W. R. Meyer, pp. 123-139); "Present Status of Electrodeposition of Tungsten from Aqueous Plating Baths" (M. L. Holt, pp. 139-148); "Films and Their Relation to Cleaning Before Electro-plating" (C. Johnson, pp. 149-161); "Review of Electro-plating Research at Indiana University" (F. C. Mathers, pp. 162-170); "Calcium Chloride Corrosion of Plated Automative Parts Can and Should be Reduced" (E. M. Baker, pp. 170-185); "Some Factors Governing Ductility of Nickel Electro-deposits" (E. A. Anderson, pp. 185-197); "Brass Plating for Rubber Adhesion" (H. P. Coats, pp. 198-217); "Properties of Fused Alumina Grain for Polishing" (A. A. Klein, pp. 218-224); "Effect of Nickel Chloride in Nickel Plating Solutions" (M. Waite, pp. 225-232); "Drag-Out" (G. Soderberg, pp. 233-249); "Effect of Polishing on Corrosion Resistance" (W. M. Phillips, pp. 249-254); "Electrodeposition of Zinc" (G. B. Hogaboom, pp. 255-264); "Electrodeposition of Nickel on Zinc" (J. M. Cosgrove, pp. 265-275); "Buffer Chemicals in Nickel Solutions" (D. A. Cotton, pp. 276-280); "Effects of Composition and Structure upon Corrosion of Nickel Anodes" (A. G. Spencer, pp. 283-298); "Process Control and Finishing Costs" (M. L. Farber, pp. 299-305); "Comparative Evaluation of Modern Finishes" (L. Roon, pp. 305-308).

As will be seen the papers and discussions cover a very wide range. The American Electro-Platers' Society is doing very useful work and the present publication deserves the attention of all who are interested in electrodeposition.

The Importance of the pH Value in Alkaline Electroplating Baths

An Entensive Abstract

by WALTER R. MEYER

Abstracted from — (Die Bedeutung der pH — Zahl in den alkalischen Bädern der Galvanotechnik) RICHARD SPRINGER — *Die Metallwaren —Industrie und Galvano — Technik No.* 14, Vol. **34**, July 15, 1936, pages 269 - 270. While the importance of pH control in nickel baths is well known, little has been published relative to the effects of pH changes in alkaline plating baths where the pH effects are no less important.

Brass Baths

The brass bath is one of the most difficult of the alkaline plating baths to keep in order. Many times a bath with the proper concentrations of metal,

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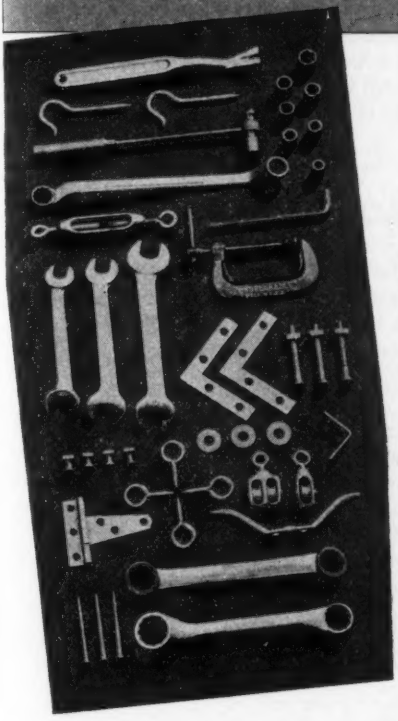

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free cyanide, etc., will fail to perform properly. The following results were obtained by variations in pH:

1. In the pH range from 9.8 to 10.2 the bath worked without difficulty.
2. At a pH of 10.3 the first specks appeared. With increasing pH, the specks became more numerous and about 11.0 pH the deposit had a dirty, olive-green appearance.
3. When the pH was raised higher, the appearance of the deposit became better and finally at 12.5 took on a uniform tombac (red brass) color which remained constant until a pH of 13.5. Experiments with very pure metal salts and various commercial salts gave similar results but with a slight change in the pH intervals (Compositions of solutions not stated). From the above results the bath should be operated with pH's between 9.8 and 1.02. For a red brass color, operate with a pH above 12 and use red brass anodes.

Cadmium Baths

Every operator of cadmium baths has experienced the vexing problem of peeling or blistering which was formerly attributed to free cyanide or alkali. Tests on commercial baths, however, showed that the adhesion became better as the pH increased. Laboratory experiments showed that the deposits were most adherent for cadmium deposited from solutions having a pH from 12.0 to 13.0. Under pH 11.5, the deposit peeled when the steel sheet upon which it was deposited, was bent. Above 13.0 the adhesion diminished slightly. Occasional cases have been observed where exfoliation was caused by addition agents used as "brighteners".

Copper Baths

The influence of pH on cyanide copper baths is not as pronounced as with brass and cadimum baths. It was observed that baths with high free cyanide content blistered with current densities between 1 and 3 ampres per square foot if the pH was below 10.7. On the basis of the experiments made, the optimum pH range is from 10.7 to 11.0 Above 12.5 the deposits are finer grained but darker. The fumes from baths with high pH's (above 12.0) are particularly troublesome to the workmen.

Zinc Baths

Alkaline baths with pH's above 13.5 work most satisfactorily which is in agreement with the experience of American workers.

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Business and Social News

BRANCH NEWS

Educational Activities

MILWAUKEE BRANCH

Milwaukee Branch held its regular monthly meeting August 13, President Dexter Rhodes presiding.

Our Librarian Henry Bornitzke read a very interesting paper on High Temperature Chrome Plating. He promises a fine educational schedule for this fall.

Jack Geissman picnic chairman, Bob Steuernagel, Paul Krause and Roman Binder, committee, were discharged with a rising vote of thanks, for a job well done.

The Branch will have its Annual Booster and Every Member Present meeting October 8. The board of managers have promised a lunch with refreshments.

We have two applications for membership, Mr. Ed. Sheehan, Milwaukee and Mr. Earl Smith, of Fort Atkinson.

Milwaukee Branch membership has been growing steadily this past year.

R. C. BINDER, *Sec'y*

CHICAGO BRANCH

The regular monthly meeting of Chicago Branch was held September 12, 1936 at the Atlantic Hotel.

President G. Jelinek presiding and all officers present.

A motion was made and seconded that Chicago branch hold its annual banquet in January 1937 and a committee was appointed on same.

Mr. F. J. Hanlon as chairman of the picnic committee reported on the picnic and thanked all the members of the various committees for their very fine work.

Mr. R. Hazucha reported on the baseball game, Mr. M. Longfield reported on the games and the secretary read the financial report. It was the opinion of all the members present at this meeting that the picnic was a huge success as everyone stated that they had a very fine time at the picnic.

President Jelinek then discharged the committee with a vote of thanks.

Mr. O. E. Servis reported that Mr. T. Donnelly's health was improving and that Tom could receive company, it is hoped by all the Chicago Branch members and officers that Tom will soon be back in normal health.

In spite of the hot night the attenance was large at this meeting and all members not attending meetings are losing out on some very interesting discussions. The librarian Mr. O. E. Servis stated that he hoped from now on thru the cool months to have a different speaker at each monthly meeting. All members are urged not to miss these interesting talks.

The librarian found the following questions in the question box.

No. 1. *What can be used for a brightener for a Tin solution?*

Answer. Sodium perborate, and one member stated that he used 3 lbs. of Arabic Gum dissolved in hot water and added to 500 gal. tank for a brightener.

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No. 2. How much Boric Acid will dissolve in a Nickel solution at room temperature?

Answer. A member stated that he was only able to dissolve 4 oz. of boric acid to 1 gal of Nickel solution at 70% but after adding sodium sulphate to the nickel solution he was able to get 9 oz. of boric acid into the solution per gal.

No. 3. Is caustic potash especially freer rinsing than caustic soda?

Answer. Yes.

No. 4. What is a good solution to make a Jet black on aluminum?

Answer. It somewhat depends on the aluminum, but a caustic soda dip, then rinse, and run thru a perchloride of iron dip and lacquered gives a very nice finish.

J. W. HANLON, *Sec'y*

HARTFORD BRANCH

The Hartford Branch of the A. E. S. held its first fall meeting on Monday, evening, September 14, 1936 at the Hartford State Trade School, Hartford, Conn.

The meeting was called to order at 8.30 P. M. with President Chas. Peterson in the chair. Minutes of the previous meeting were read and accepted. One bill for our first quarter per capita tax and Convention Proceedings Copy was voted to be paid. Two communications were read and discussed.

Under new business, Mr. W. D. MacDermid was selected to act as Chairman of a membership drive committee.

Much discussion took place in planning the activities for the coming year. Many good speakers are to be engaged for the various monthly meetings.

An annual outing was planned to take place on Saturday, September 19, 1936. Notices to that effect have been sent out to all members.

The meeting was attended by eighteen members and was adjourned at 10.00 P. M.

Hartford Branch held an outdoor Stag Party on Saturday, September 19 at Mr. Bill Stoddard's cottage in Old Lyme Shores, Conn. Dinner was served at 1.00 P. M. Supper at 6 P.M.

In between, the usual games were indulged in — soft ball, horseshoes, cards, golf and swimming. The affair was very successful; a good number from the local and other branches being present.

The committee consisted of H. W. MacFayden, W. D. MacDermid, Wm. Stoddard and W. E. Bancroft.

VERNON E. GRANT, *Sec'y*

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GRAND RAPIDS BRANCH

Grand Rapids Branch opened their fall and winter meetings with a fair attendance.

One of the outstanding events of the evening was a report from Mr. J. B. Hawley, who is Chairman of our membership drive committee on the campaign he and his committee are going to put on.

I have every reason to believe our membership will increase.

CHAS. S. WHALLEY, *Sec.-Treas.*

CLEVELAND BRANCH

The regular monthly meeting of the Cleveland Branch of the American Electro-Platers' Society was held at Hotel Carter, Saturday, September 12, 1936.

The meeting was called to order by our president, Mr. William D. Scott, at 8.15 p. m. The minutes of the previous meeting were approved as read.

Application for associate membership was made by Mr. Terrance O'Neil, 214 Morrison Avenue, Cuyahoga Falls, Ohio.

Application for associate membership of Mr. R. W. Renton was turned down by our board of managers due to lack of experience as assistant pl[illegible]

Mr. Singler reported that the Clam Bake to be held Saturday, September 26th should be a big success due to the advance sale of tickets. Mr. Scott was ordered to get in touch with the master of ceremonies that we had at the Convention picnic and have him preside at this function.

Our librarian Mr. Carlson then read a very interesting paper on "DRAG-OUT" by Mr. Gus Soderburg of the Udylite Company, a very lively discussion followed this important paper.

Mr. Carlson was then given a rising vote of thanks for his selection of this reading.

There being no further business a motion was made to adjourn.

W. E. O'BERG, *Sec.-Treas.*

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WATERBURY BRANCH

Regular meeting of Waterbury Branch A.E.S. was held Friday evening, Sept. 11th in Engineer's Hall; Tennant Elwin, president, presided. Plans were outlined for the coming fall and winter activities. Librarian Candee reported that two excellent speakers had been secured for the October and November meetings.

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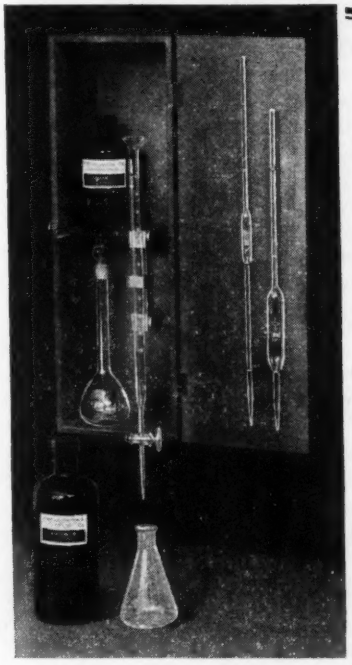

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CHICAGO

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It is expected that within a short time a committee will be appointed to cooperate with the national membership committee, which has for its object the rounding up of all eligible candidates for the A.E.S.

The Branch was fortunate in having as a visitor, Mr. Arthur J. Mintie, president of Boston Branch, who gave an account of plating activities in this city and vicinity a quarter of a century ago. Mr. Mintie is the son of the late James Mintie, a local pioneer in the plating business and who helped in no small manner in gaining for Waterbury its reputation as a plating center. During the evening a number of topics came up for discussion which proved interesting to all.

W. F. GUILFOILE, *Sec'y.*

DETROIT BRANCH

The regular meeting of the Detroit Branch of the American Electro-Platers' Society was held at the Hotel Statler, Friday evening, September 11, with Mr. A. B. Wilson presiding.

This being the first meeting since May 1st, there was a good attendance, the officers all being present. The reading of the minutes of the previous meeting of May 1st was dispensed with. They were approved as published in the June "REVIEW".

There was one application for membership — Mr. Maxwell M. Wise, of the Parker-Wolverine Company, made application for active membership. This was referred to the Board of Managers, to be reported on at the next meeting.

Mr. George L. Nankervis gave a report on the picnic which was held August 8th. He reported it a wonderful success, and we expect to have it an annual event in the future. It was also recommended that we have a party or banquet of some sort during the winter.

Mr. A. B. Wilson, our president, then gave a report on the entertainment of the convention held in Cleveland on June 1st through 4th, inclusive, Mr. Cherry who was delegated to make his report not being present on account of illness at home. Mr. Wilson then gave a very comprehensive report of what the Cleveland Branch had to offer in the way of entertainment.

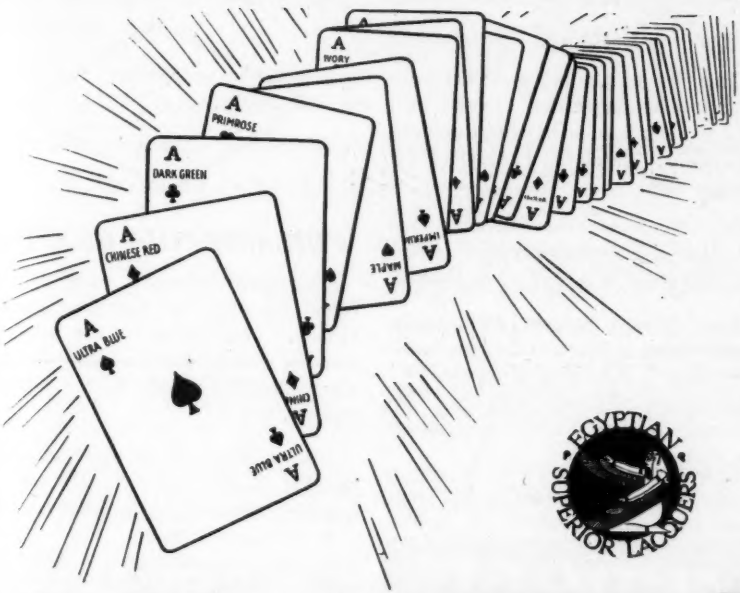
Mr. T. C. Eichstaedt, our Secretary-Treasurer gave a report of the business transactions of the Convention. This report covered all the business transacted at the Convention, as published in the "REVIEW."

Mr. A. G. Spencer, of the Chevrolet Motor Company of Flint, Michigan, gave us a report on the technical papers which were read at the Convention. Mr. Spencer abstracted practically all the papers and gave us a wonderful paper on these abstracts. He covered them very thoroughly, and anyone who did not attend the Convention and attended this meeting certainly knew by Mr. Spencer's abstracts what it was all about. I do not happen to have a copy of Mr. Spencer's abstracts, and he did not think they were good enough to be published.

Mr. George L. Nankervis was appointed Chairman of the new Membership Committee for the year, and we are expecting great things of this committee.

The following questions were found in the Question Box which was conducted by Acting Librarian, Mr. B.F. Lewis.

(1) *What causes nickel to plate dark in recess of work after the nickel salts have been added to the solution?*



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Ans: Impurities in the nickel solution. Remedy suggested — work it out, by working it hard on hanging dummies for a while. Watch the P. H. that it is not too high.

(2) *Has anyone ever observed a dark red color in a cyanide copper solution, and what might be the cause and remedy?*

Ans: Yes, it is quite common in copper cyanide solutions. The probable cause is polarizing of anodes and copper oxide. No cure proposed. The sure remedy is to discard the solution and make a new one.

(3) *What are the relative merits of direct and reverse current in electric cleaning of steel and non-ferrous metals?*

Ans: Reverse current has its advantages over direct, but the strength of cleaning solutions has to be kept up to standard. There is less corrosion on the work when it is used in connection with direct current, although there are some platers who never use direct current on electric cleaners and have very good success in cleaning.

(4) *What is the best non-pitter to use for nickel? Are the wetting agents superior to peroxide to stop pitting?*

Ans: No best non-pitter recommended, but it is claimed by the manufacturers of bright nickel polishes that the brighteners added to the regular nickel baths will stop pitting, and that it is better to use these than peroxide. There are many of these wetting agents, so-called, on the market, but there is none of them preferred in this answer.

(5) *What is the effect of varying P. H. or alkalinity in a cyanide copper bath?*

Ans: Too much alkalinity gives less anode corrosion, consequently keeping less metal in suspension, and slower deposit results.

The meeting was adjourned at 10:30.

T. C. EICHSTAEDT, *Sec-Treas.*

PHILADELPHIA BRANCH

Philadelphia Branch meeting was called to order by President Albert Hirsch. The minutes of the previous meeting were read and approved. Roll was called, all officers but one being present.

Dr. Edward B. Sanigar was the Speaker of the evening. He gave a splendid talk on how to prepare a paper —a very timely topic. We hope to have this address printed in THE REVIEW in the near future.

Mr. Sanigar's address was so interesting and well received that a general discussion followed. At the conclusion of the discussion it was voted that Dr. Sanigar be appointed to help any member write a paper or make a report of his work.

Philadelphia Branch will hold its annual meeting and banquet, November 21, 1936. The educational session will start at 2.30 P. M. The banquet will start at 7.30 P. M.

There will be an award for the best paper read at the educational session by the members. There will also be an award for the best exhibition of work presented by any of the members.

The Chairman appointed Mr. Fulforth and Mr. J. Dinan as the door prize committee. Remember the day November 21, 1936. The place: Adams, 13th and Spring Garden Streets. Bring a friend, also try to bring your Superintendent or some of the officials of your place of employment.

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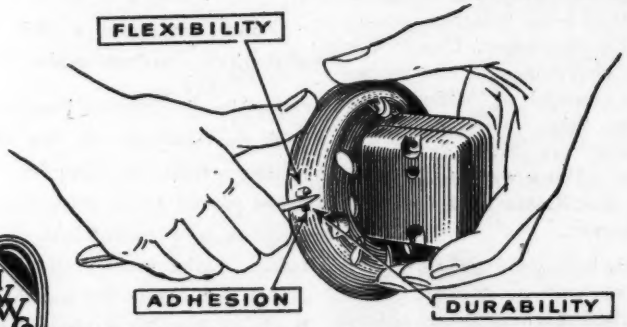

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An application from Mr. J. E. Krajewski as an associate member was reported favorably by the Board of Managers. Mr. Krajewski was therefore elected an associate member of Philadelphia Branch. There being no further business, the meeting adjourned until October 16 at 7.30 P. M.

R. E. JACKSON, JR., *Sec-Treas.*

BRIDGEPORT BRANCH

The Bridgeport Branch held its annual outing on Saturday, September 12 at Eichar's Grove. Members and friends were present from Waterbury, New Haven, Hartford and Springfield. There were about seventy present. During the day there were races, games and horse shoe pitching contests. In the afternoon a softball game was held between the platers and peddlers, the usual arguments enlivened the game, the spectators being more than usually interested in the contest. Charlie Costello, the chairman, was the umpire and did a good job of "calling them" considering "the interference". A steak supper was served as the sun went down. Prizes were given to the winner by Doc Kellner of the Lea Mfg. Co., Bridgeport.

Everyone had a good time and agreed that outings such as this are a good thing for the Branches to foster at least once or twice a year.

CHARLES C. COSTELLO, *Sec-Treas.*

ROCHESTER BRANCH

The Rochester Branch held its regular monthly meeting on Friday night, September 18. Meeting called to order by President Kohlmeier. Minutes of previous meeting read and approved as read. Communications were then read and commented on. Secretary ordered to turn letter in regards to speakers over to Chairman John Honnecker of the Educational Committee. The President then made a few timely remarks and then turned the meeting over to our Educational Chairman. The subject discussed was "Cyanide Copper Plating" and a real lot of information and ideas were discussed. Following this the meeting was adjourned.

JUDSON R. ELSTER, *Sec'y*

BINGHAMTON-ELMIRA BRANCH

The Binghamton-Elmira Branch of the American Electro-Platers' Society held their monthly meeting September 8th, at the Y.M.C.A., Binghamton.

Dinner was served at 6.30 P. M. after which a business session was held.

Joe Hermis of Oakite Products, Inc., held the spotlight of the evening, reading a paper on "Cleaning." The paper proved to be exceptionally interesting and educational. Cleaning being a major problem of plating we all feel indebted to Joe and the Oakite Products, Inc., for a pleasant evening and valuable information.

It was decided to hold our next meeting the first monday in October.

LARRY MEYER, *Sec'y*

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NEWARK BRANCH

The regular meeting of the Newark Branch of the A.E.S. was held on Friday evening, October 2, 1936 at the Krueger Club. The meeting was called to order at 8:30 P. M. with President Samuel Taylor presiding. All officers were present. The minutes of the previous meeting were read and approved.

An application for Mr. Louis J. Donroe was voted on to take the regular course.

Mr. George Wagner reported that the Clam Bake, due to the heavy rain of the day before, was not quite as successful financially as it might have been if more of the members would have come out to support the affair. He also mentioned that all who attended were well satisfied and had a wonderful time.

Arrangements are being made for a Bingo party to be held at the Krueger Club on November 6, 1936. The Holding Committee to have full charge over that affair.

Mr. Paul Oldam who has recently returned to our fold was elected Librarian for the ensuing year.

Mr. Oliver Sizelove, the speaker of the evening, gave an interesting talk on "Bright Deposits of a Cadmium Alloy" on steel and cast iron. He stated that Cadmium Alloy would stand a 30% longer salt spray test than pure Cadmium of equal thicknesses of deposits. Mr. Sizelove exhibited some samples to show the brightness and throwing power of this particular solution and stated that within a short time the Cadmium Alloy Solution would be commercialized. Mr. Sizelove was given a rising vote of thanks by the 32 members present at the meeting.

Meeting adjourned at 10:30 P. M.

GEORGE WAGNER, *Sec'y*

SAN FRANCISCO BRANCH

At the last meeting of the San Francisco Branch, the following officers were elected:

Lawrence Miller, *President*, Enterprise Plating Works, 780 - 22nd. St., Oakland, California.

Bernard Hibberson, *Vice President*, Phoenix Plating Works, 461 Bush St., San Francisco, California.

John Glassner, *Librarian*, 437 Douglas St., San Francisco, California.

Henry Neirings, *Secretary-Treasurer*, 219 Gleeson Ave., Vallejo, California.

The above officers will be installed at a dinner meeting to be held in Oakland in the near future.

We feel that with the return of prosperity in the plating industry and with an aggressive set of officers, the San Francisco Branch is again heading for great things.

I would here like to make mention of the yoeman work done by Mr. Louis Delamothe and Mr. Bernard Hibberson. Both members have put forth untiring efforts in the interests of the society and have donated the use of their offices for meeting places.

I also cannot overlook the work of Mr. Joseph Levoy, the "Grand Old Man" of our organization. He organized the Branch, secured most of the members and served as a delegate to the National Convention, at his own expense.

H. W. MCKIBBEN, *Sec'y*

BOSTON BRANCH

Boston Branch will open its fall and winter sessions Thursday, October 15, 1936 at the Manger Hotel at 8:00 P.M.

This is going to be an open meeting, so that you can bring your families and friends. Bob Leather of the Lea Manufacturing Co., will be our guest. He will show us the moving pictures taken

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at our outing, held at the Pemberton Inn, July 25th, also those of the 1934, 1935 and 1936 A.E.S. conventions. This certainly will be a treat for everyone.

Come see yourself and friends in the movies. Our attendance will show Bob Leather how much we appreciate his efforts in presenting these pictures to us.

We have several attractive plans for this winter, which your committee wish to present for your opinion. This concerns our speakers, chemistry class and social functions.

Refreshments will be served after the meeting. Come start our 1936-1937 season with a bang!

ANDREW W. GARRETT, *Sec'y*

Membership Report

To September, 18, 1936

ELECTIONS

William J. Porter, 147 E. Parkwood Drive, Dayton Ohio
Active, Dayton Branch

J. Edw. Krajewski, 4445 E. Thompson St., Philadelphia, Pa.
Associate, Philadelphia Branch

APPLICATIONS

Mr. Earl A. Smith, 423 East Street, Fort Atkinson, Wis. Active

Mr. Ed. T. Sheehan, 544 No. 20th St., Milwaukee, Wis. Active

Louis J. Donrae, 719 High St., Newark, N. J.
Associate, Newark Branch

William Francis Maher, 560 W. Third St., Fulton, N. Y.
Active, Binghamton Branch

SUSPENSION

Mr. Wm. Kuehle, Two Rivers, Wis., has been suspended by the branch.

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